SMART Oral Health

The Medical Management of Caries

Edited By:

Dr. Steven Duffin, DDS

Jacqueline Juhl, RDH, BS, MS

Dr. Joseph Schwab, PhD

Marcus Duffin, MS, MBA

Published in 2019 by Oral Health Outreach, LLC
Printed by Kindle Direct Publishing

ISBN: 9781707659074

Library of Congress Cataloging-in-Publication Data
SMART Oral Health The Medical Management of Caries/edited by Steven Duffin, Jacqueline Juhl, Joseph Schwab, Marcus Duffin
Includes bibliographical references and index.

Designer	Marcus L. Duffin
Index	Steven. R. Duffin
Layout	Marcus L. Duffin
Cover Designer	Marcus L. Duffin
Cover Image	Geoff Knight
Text Editors	Steven R. Duffin, Jacqueline A. Juhl, Joseph Schwab

Foreword

(Dr. Karen Sokal-Gutierrez, MD, MPH)

As a physician with training in pediatrics, preventive medicine and public health, I received *no* training on oral health in my medical and public health education. However, through my work in children's health in the U.S. and globally over recent decades, I've observed that the majority of children globally suffer from untreated dental caries, and oral health has been tragically neglected in medicine and public health. I now know that ensuring good oral health is critical to the overall health and wellbeing of children and adults, and I've been driven to learn more about oral health by reading the literature, consulting dental colleagues and attending dental conferences. In the course of my immersion in the dental world, I've also observed that medical and public health professionals have important information and perspectives to share with dental professionals. So I've committed myself to working inter-professionally among medical, public health and dental professionals. We can learn from each other to incorporate oral health issues into medical and public health services, and to incorporate medical and public health issues into dental care.

This SMART Dentistry book summarizes the microbiological underpinning, techniques, effectiveness, and clinical and public health potential of silver-modified atraumatic restorative treatment (SMART) for dental caries. Having observed these treatments in the field, I strongly believe that they can be a "game-changer"—they can contribute to promoting more widespread, accessible, affordable and effective prevention and treatment for dental caries globally, and dramatically reduce suffering, for children and adults.

I encourage readers to review this book, and dig deeper into the chapters of greatest interest. You may find that you are driven to fully understand the microbiology of caries and the antibacterial mechanisms of silver ions. Or you may find that a basic understanding of the microbiology is sufficient—just as we use telephones and computers every day with only a basic understanding of how they work—but focus your attention on techniques to apply in your clinical practice.

I also encourage readers to remember to periodically step back from the details of SMART to maintain an overall public health perspective on oral health. Dr. Jeremy Horst, in his chapter on the Biological Mechanisms of Silver Diamine Fluoride, concisely described the causes of tooth decay, "The results of enormous volumes of work from across the globe over the last century and a half is that: caries is caused by sugars being fermented by dental plaque bacteria into acids which then dissolve the tooth." While this SMART Dentistry book immerses you in the latter two factors—dental plaque bacteria and treatments to suppress them, and tooth structures and treatments to support them—I encourage you to pay equal attention to the primary cause of caries: added sugar in foods and beverages. We need to understand the economics and politics of the increasing global marketing and widespread daily consumption of sugar, and sugar's contribution not only to dental caries but also to our pandemics of obesity, type 2 diabetes and cardiovascular disease. In addition to providing high-quality clinical care—including SMART dental techniques—dental, medical and public health professionals must advocate together for public policies and education to limit sugar consumption, and improve access to healthy food and clean water, to improve the oral health and overall health of our population globally.

Preface

Dr. Steven Duffin, D.D.S.

Many years of thought and practice have gone into the compilation of this manuscript. The title, *SMART* is an acronym derived from Silver Modified Atraumatic Restorative Treatment. However, there is a deeper meaning implied, because it is the hope of all the contributors that the reader will come away with a somewhat “SMARTER” understanding of new treatment techniques for two oral conditions: caries and periodontal disease, the most common afflictions of humans. Our purpose is to provide a guide of new clinical approaches to better serve our patients. Another goal is to encourage investigation by qualified scientists, into the various knowledge gaps that presently exist in this field.

We are living in an era when equitable access to oral health care is both a common topic of discussion and a challenge. Globally, there exists a disconnect between the number of active dental practitioners and the number of persons most in need of regular preventive and restorative oral healthcare services. Which in turn affects not only the sequela of systemic diseases, but the general quality of life as well. In this text, and as a remedy to this disparity, we suggest that a *more important concep*t would be a *reduction* in the demand for care, via the prevention of disease and resultant improvement in general wellness.

There now exists both knowledge and technology that promises to deliver on both counts.

However, there also remain significant knowledge gaps about the etiology and epidemiology of oral diseases, together with an absence of optimal and well-established treatment protocols. Nonetheless, combination therapeutic strategies using silver ion products, fluorides, and glass ionomers, provide powerful tools to extend our reach to serve those in need of oral health care services. None of the authors of this text claim to have a complete understanding of the causes of dental diseases, or what the ideal treatment for any given individual may be. Perhaps by becoming exposed to the variety of opinions and experiences found in this book, the reader will be better empowered to make recommendations for evidence-based oral health treatments. It is our desire that by reading this book the reader might join with those of us who are committed to improving the oral health for *all* humans *everywhere* on this planet.

The use of the terms silver nitrate, silver fluoride, silver diamine fluoride and silver ion compounds will appear interchangeably throughout the text. Presently, various high-level clinical trials are underway to attempt to distinguish the efficacy of these similar but distinct products. The choice of one term over another may derive from a historical context or from individual author perspectives. There are few, if any, recent high-quality research studies on the subject of silver nitrate in caries treatment, because this product fell out of favor during the 1950’s. Silver Diamine Fluoride and in particular the 38% version of this product, has been the subject of many recent investigations. The reader should keep this distinction in mind throughout the text.

This manuscript is wide ranging and represents the thoughts and experiences of many people whom we have come to consider to be the leading experts in this evolving field. We have asked scientists and clinicians in both the private and public health sectors, who are actively working in this discipline, to contribute their experiences, their findings and interpretation of the growing literature on this subject. Some authors' perspectives may be influenced by their geographical settings, academic positions, or practice environment. We hope that this diverse set of ideas might contribute to a robust exploration of our subject. In addition, because of the large number of participating authors, the reader will be exposed to many different styles of communication, some methods of referencing may be author specific, please keep this in mind while moving throughout the text. There may also be some repetition of particular subject material as described from the individual author perspective.

We believe that that this is a strength rather than a weakness although it will require the reader to adjust to these individual author writing styles.

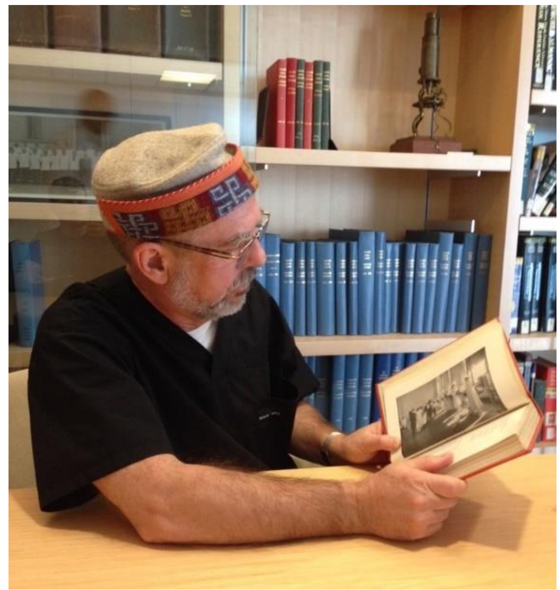
There is no hidden agenda found here. Some author positions may be cause for discomfort to various audiences. As Thomas Kuhn has stated about Paradigm Shifts:

"There may be some pain experienced by institutions that feel the pressure of change as movement toward the new standard occurs."

Starting from the 60,000-foot level, I (Steve Duffin SD) have tried to explore the history of bacteriology and cariology from the perspective of the pioneers who built the scientific foundation upon which we stand.

Throughout this text, we will take a journey from the first glimpse of oral bacteria by Antonie van Leeuwenhoek in the 17th century, and on through the founding fathers of the germ theory of disease, and medical microbiology. We will explore the strange and interesting intersection between medicine and the emerging dental profession.

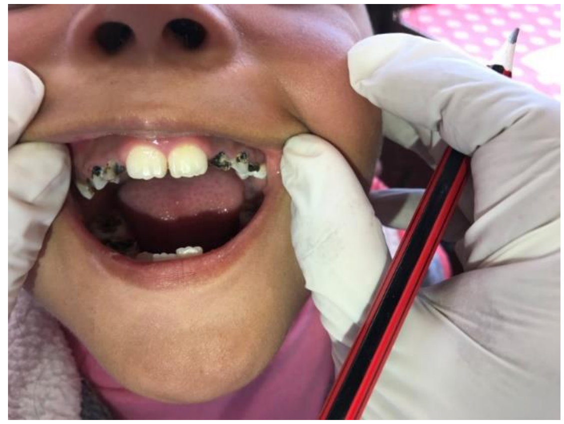
A rapid tour through the most recent one hundred years will then bring us to the present time and an exploration of the magnificent tools of molecular biology. This journey will allow us to look beyond bacterial morphology. Rather, we



Dr. Duffin at the Forsyth Institute archives.

will explore bacterial genomic expression and biofilm physiology from an ecological perspective. As I (SD) write these words (September 2017) I am presently at Copacabana, Bolivia, located on the south shore Lake Titicaca conducting a humanitarian outreach program for children of Incan descent. Today, we examined over 400 primary school children and found only ***three*** children without ***any*** signs of tooth decay, an astonishingly sad discovery.

Lake Titicaca, Bolivia.



Copacabana, Bolivia 2018.

Postscript: today (March 4, 2018) we just completed six-month post treatment examinations on those very same children mentioned above. The collected data will be published at a later date. The treatment protocol for these school children was to carefully clean and dry each caries lesion, apply 38% SDF with a microbrush, and immediately cover with fluoride varnish. This protocol protects the treated surface from saliva contamination and masks the bad taste of SDF. At the time of initial treatment, 50% of the children enrolled in this program complained of regular caries related mouth pain. **My first and most astonishing observation was that not one child complained of mouth pain at this six-month evaluation.** We examined thousands of lesions which appeared clinically arrested as determined by the criteria of color and surface hardness.

We encountered many children with transition dentitions whose healthy erupting *permanent* teeth co-existed with caries-arrested *primary* teeth. One would hope that their future new caries experience will be diminished. This is an area which requires further scientific investigation.

Being concerned about the numerous dark stained and caries arrested teeth that we found, I asked the children themselves, their teachers, school administrators and parents about any concerns regarding this color change. The universal response I received was that they were glad that the children's teeth had ceased to hurt. This remarkable finding contradicts the suggestions by many dental professionals, that parents would never tolerate this color change treatment outcome.

It is important to note that the social determinants of disease in the phenomenon of caries are a crucial part of this story. We hope to give adequate credit to those who blazed the trail of this discipline. The disease of caries is a result of the *interaction* of bacteria *and* host factors, including diet, and ***not*** just the mere presence or absence of certain types of bacteria in the human mouth. This vast multifactorial and multispecies complexity may explain why we are *still* fighting an uphill battle against caries, the most common infectious disease of humans.

I understand that there are various groups of experts who will object to my use of terms like *infectious disease* when describing caries. I have tried to consider all points of view and admit my own bias (SD) being first trained as a microbiologist. Perhaps the one thing we can all agree on, is that we are far from conquering this condition, there remains much work ahead of us and many children remain awaiting our assistance.

Next, we explore the remarkable story of fluoride in its various forms and, more recently, the introduction of a fluoride containing therapeutic restorative material, glass ionomer cement (GIC). It is the combination of silver ion products, fluoride, and glass ionomer materials that creates a therapeutic strategy which brings such power to prevent and control caries in populations around the world today.

This book will offer many references to multi-media material which may be accessed on the internet and which compliment this text. <u>I encourage the reader to take the time to watch the interviews and demonstrations that are found there</u>.

As a reference text, it may make sense to read the sections, in the order that is preferred, rather than to read the text front to back in its entirety. I believe that this manner of learning is beneficial, especially in a field of study that is in its infancy. Several chapters constitute the collective life work of pioneers in this field. <u>*As a reminder and to avoid reader confusion, the topics which are sometimes repeated in this book, are presented from different author perspectives of timeframe and clinical experience and expressed in their unique writing style*</u>. Some topics may appear in duplicity. This may be true, but I remind the reader that pioneering experts in any emerging field will possess their own unique perspectives and manners of communication.

I (SD) must emphasize that we are in the early days of this approach to clinical patient care. There remain many knowledge gaps. However, at this time there exists sufficient evidence to support a serious examination of these techniques. Credible clinicians are reporting remarkable clinical outcomes using a variety of combination protocols and scientists are now beginning to ask serious research questions and to explore them with our most powerful technologies and with academic rigor.

"I personally take responsibility for any and all errors that appear within this text. Of course, history teaches us that what is considered to be an error today may be found to be a truth tomorrow." -Dr. Steve Duffin, DDS

Additionally, to understand my (SD) motives for writing and producing this text, I offer that I do not consider myself to be a proper "scientist", only an ordinary dental clinician with curious tendencies. I also apologize for the wide use of first-person narrative in this text. This subjective manner of communication will no doubt be offensive to some of my more academic colleagues. However, my intended audience is far wider. I am deeply committed to the scientific method as a way of explaining the physical world, however the writing style which we have embraced, may assist with sharing our message into a broader audience.

While it is not possible to adequately recognize the many individuals that have contributed to this text and who influenced my career, I (SD) would like to give special thanks to my two principal scientific mentors, Dr. Lindsay Hunt and Dr. John Yagiella, who both inspired me in the quest for scientific knowledge and who allowed me to spend most of my dental school years working and learning in their laboratories at Emory University many years ago.

Special thanks as well to Dr. Peter Milgrom. It was from him that I first heard the words silver fluoride.

My father, Dr. Ralph Duffin has been an example and inspiration as my dentist mentor throughout

life, particularly as a volunteer dentist working in orphanages in Vietnam. I remember stories and photographs showing hundreds of children lined up for extractions during those mission trips. It seemed very sad to me that treatment arrived so late when children were suffering from advanced dental disease and in need of surgery.

Dr. Ralph Duffin in Vietnam.

Hearing these stories, I began to ask the question, “What if there was a better way?**” Could the “better way” be earlier treatment and the use of a biologically-sound medical approach, *rather than a late stage surgical one, to treat dental disease*?** I believe that we have seen this hope come to pass and manifest in this book. Many oral health heroes across the globe contributed to making this book possible, to each and every one I extend my deepest gratitude. I would also like to thank my wife Joanne S. Duffin for providing a variety of different photographs in this book.
May we travel the road toward knowledge and truth without abandoning that human spark which inspires us to serve and help those we meet along the way.

Jacqueline Juhl, RDH, BS, MS

Co-Editing this book has been the most important work of my life to date. Why? As a child of a military family who lived and traveled throughout the United States and lived overseas, I became aware that the world is a very big place, but that not all its peoples had the same opportunities to access very basic things like clean water, food security and good nutrition, access to regular dental and medical care, and a safe place to live. From sharing my mother’s homemade snacks through a wire fence with Japanese children, and later, with other children in the streets of Mexico, and still later, while visiting developmentally disabled children in Louisiana, I began to ask many questions about the differences in the opportunities I had and the lack of opportunities many others did not have. With time, I became increasingly dissatisfied with the pat answers I received to my questions about these differences. From all I had learned from my family, my faith, and from something within, these “differences” just did not seem “right” to me. I wanted to know more about these differences and why they existed. I was often told, “Find out for yourself!”, the likely nidus of my passion for learning and research.

My forty-plus year professional career began in clinical nutrition, but I came to dental sciences after marrying my dentist husband, my first dental science mentor. His professional ethics, compassion for his patients, and his knowledge and skills of dental sciences inspired me to become a dental hygienist, but, again, there was so much more to learn, so many unanswered questions about the oral disease experiences of those we treated as a team. I completed a second baccalaureate degree where I began assisting in oral health research as a volunteer. I also took two special fellowships to better serve persons with a vast variety of mental and physical disabilities in our rural private practice because few other dentists in our area would accept these patients. Their needs were great, and their caregivers lacked preventive knowledge and skills to maintain their patients'

oral health.

During graduate school, my view of global oral health exploded. As a volunteer with a Non-Governmental Organization, and as part of my dual-emphasis graduate work, I provided educational and clinical services in nine countries in the South Pacific and Central and South America where I directly witnessed the inequities of access to oral healthcare, the needless pain and suffering of oral cancers, rampant caries, devastating periodontal diseases, and rare oral pathologies. The more I saw and treated, the more questions arose. Convinced that there must be better ways to address these devastating oral diseases, I sought tools to seek, posit, and test possible answers. Enrolling in the University of Washington School of Dentistry Summer Institute for Dental Research Methods seemed like a step in the right direction. What I learned about oral health research methodologies not only helped me discern the *science and sense* from the *nonsense* which abounds, but it helped me better understand and appreciate the sciences, methodologies, efficacy, and logic of treatment strategies of the *Medical Management of Caries*. Cumulatively, these experiences have only deepened my conviction that, as individual parts of a comprehensive health team, dentists, dental hygienists, and medical providers must unite and demand *upstream answers* to better address the increasing global oral disease crisis to answer:

- *WHY* is oral health such a low priority in many governments when *now* we have, not just bio-plausibility, but quality research demonstrating oral-systemic inter-relationships and their impact on disease sequalae and life quality and longevity?

- *ARE* extractions the *best* we can do for the people of developing countries?

- *WHY* are addictive sugar food and drinks ubiquitous and more accessible than clean water?

- *WHY* can't we educate and enculturate caregivers to the value of preventive care for the most vulnerable members of our world: children, the disabled, the aged, *before* they need surgical and restorative oral disease interventions.

As an educator, I challenged my students to find answers to such questions through critical thinking and the pursuit of advanced education including research experiences. I encouraged them to engage in evidence-based strategies which will become part of the solution!

As children, we are often asked, "What do you want to be when you grow up?" Even as a child,

Jacqueline Juhl with patient in Ghana.

the one thing of which I was always certain was that I always wanted to help make things *better*. *We*, as dental and medical providers, as Ghandi put it, "…*must be the change we wish to see in the world.*" We must change the way we practice; change the way we view the interactions of oral and systemic diseases; and change how we structure healthcare delivery systems. We must have the courage to share the re-discovered strategies and growing evidence of the *value of disease prevention* with global policy makers. I am convinced that, to educators, clinicians, and researchers, the Medical Management of Caries evidence presented in this book *will* help change the way we practice as we attempt to alleviate and prevent needless global suffering. I encourage all readers to re-evaluate their present view of oral-systemic disease treatment strategies and consider this book as a guide to help re-shape that view. To help your individual "re-evaluation", I urge you to consider the following from my former professor, Dr. JoAnn Gurenlian: "*We have to be willing to create change in our prevention models…and our understanding of what constitutes health. If we are willing to step outside the norm, we could be **amazing**. And …if not, maybe we should do something else… I want all of us to think about what we might do as individual practitioners and as a collective group of preventive specialists to **change the world**."*

Dr. Joseph Schwab, PhD

The cynical among us would say that, in life, there are only two things that are certain: death and taxes. The wiser among us would probably counter by saying that *change* is, in fact, the most certain of all human experiences. It is always with us and, in some fashion or other, we are constantly experiencing change and trying to find a way to cope with it. Some have verbalized this truth by saying, "Nothing lasts forever." Everyone has experienced this reality many times over.

The experience of change has often been likened to a sea voyage. You leave one port (for example, a set of beliefs or practices), navigate an unpredictable ocean (the "change process" i.e., the letting go of the old beliefs or practices) and, hopefully, arrive safely at your destination port (with your new set of beliefs or practices). Change, however, is not always a placid or smooth process. In New England, there is an experience called a "Nantucket Sleigh Ride." This phrase comes to us from whalers of old. After harpooning a whale, all anyone can do is grab the boat's gunnels and hang on for dear life! The whale is in charge and most likely will take you on a fierce and terrifying ride. While I doubt many of us are New England whalers, I strongly suspect that all of us, at one time or other, have experienced a personal "Nantucket sleigh ride." Change can be terrifying. However, the purpose of this text has one single purpose: to lay out for our readers a navigation chart for the change from the mechanical management of caries toward the medical management of caries. A profound shift, to be sure! This text will provide you with the knowledge and tools necessary for such a journey. It will teach you how the change from mechanical to medical management works;

what to expect when employing these techniques; and how to assess your outcomes. The text will also direct you to an extensive library of additional information, so the reader can become as technically informed as they desire.

Surely, one would ask, “Why would anyone do this?”; “Why undertake such a radical change?” Succinctly, no one undertakes a change process unless they are dissatisfied with the way things are. What if, however, you have quietly pondered thoughts like these: In good faith I was taught the mechanical management of caries. I worked hard to learn this science and to hone my fine motor skills to be an exceptional practitioner. But, what if, in my years of clinical practice I have come to learn that what I have been taught just simply does not work! I drill, I fill, and, in too many instances, the disease does not go away. If you have ever entertained similar thoughts, this text is for you! This text will provide you with the science and the techniques to actually halt decay and preserve the patient’s dentition.

As noted above, change is a process best handled in small, manageable steps. I will outline several of these steps and guide the reader to navigate them smoothly. Again, I have addressed the motivation necessary, to, if you will, come aboard the ship, leave port, and set sail on a challenging journey to a more effective professional experience. My first recommendation is to take your time. Here, I differ from others. I suggest you read the entire book. Then, as you contemplate putting into action the knowledge you will learned in the text, I suggest the following:

Find a like-minded colleague and “team up” for mutual support.

I. Carefully select a limited number of simple cases to begin your new protocol. More specifics in this will be provided later in this book.

II. Define your clinical goals with each patient.

III. Take careful pre- and post-treatment records so that you will be able to clearly assess what was achieved in each case.

IV. Frequently confer with your like-minded colleague to: compare results, ask questions, discuss problems, and celebrate your success.

V. Understand that the change you are undertaking is stressful because it is new behavior. There will be a learning curve.

VI. Reward yourself. You are bravely going into new territory for you and you deserve to be congratulated.

“This book is dedicated to all those we have been fortunate to know and serve.” Steve, Jacqueline and Joseph.

Charitable Contribution Statement

Students at the Comfort Betroh Memorial School in Ghana.

Ten percent of all profits generated from the sale of this book will be donated to the support of the schools that participated in early silver ion compound demonstration programs throughout the world. Thank you for supporting the oral health, education, and wellbeing of these wonderful children.

In Memoriam

Lynn Ironside, RDH

"As we were preparing this manuscript for release, we lost one of the great oral health champions of all time. Lynn Ironside was my mentor and colleague for most of the past 20 years. I remember Lynn retelling a story when, as a young dental hygiene student she visited Irene Newman, Dr. Fones' dental assistant and the world's first dental hygienist. There is a lot of history in this textbook. I am proud to say that I knew Lynn who knew Irene who was the very first dental hygienist. Lynn will be deeply missed."
– Dr. Steven R. Duffin, DDS

"Lynn Ironside passed away on October 5, 2017 due to age-related issues. Lynn graduated from the Fones School of Dental Hygiene at the University of Bridgeport in Connecticut and began her 60-year career as a school dental hygienist in Connecticut spending the remainder of her career as a clinical dental hygienist in Oregon. Lynn served as the Government Relations Chair and Change Agent for the Oregon Dental Hygienists' Association (ODHA) for more than 20 years and also served as President of ODHA 1980-1981 and 1990-1991. She was instrumental in expanding the scope of practice for dental hygienists in Oregon. Lynn was an active and enthusiastic member of the Advisory Board for the School of Dental Hygiene Studies at Pacific University. She was also an honorary member of Pacific University's chapter of Sigma Phi Alpha, the national dental hygiene honor society. Lynn received several awards including an ADHA Presidential Citation, the ADHA Distinguished Service Award, and the ODHA Outstanding Dental Hygienist Award. Last year ODHA honored Lynn by creating the Lynn C. Ironside Access to Care Award. Lynn served two four-year terms as a dental hygienist member of the Oregon Board of Dentistry and was the first dental hygienist in the United States to serve as president of a board of dentistry. Lynn served on the Board of Directors for both the Oregon Oral Health Coalition and the Oregon Rural Health Association. Lynn was an unwavering advocate for increasing access to care for underserved populations and for advancing the dental hygiene profession." – Lisa J. Rowley, CDA, RDH, MS

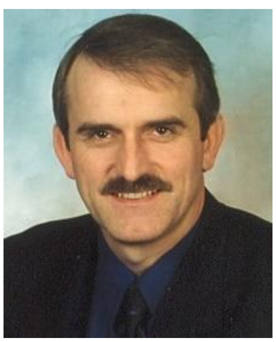
Author and Editor Information

Monika Alcorn, RDH, MPH

Author

Monika Alcorn graduated from Pacific University's Dental Hygiene Program in 2008 with her Bachelor's Degree. In 2015 she completed her Master's Degree from Idaho State University in Rural and Community Oral Health. Monika became fascinated with the medical uses of silver several years ago when she attended a presentation on the subject. That presentation was given by Dr. Steven Duffin, who has since become both a mentor and a friend. Monika is currently working in Washington State as a clinical hygienist but is also licensed in Oregon and Hawaii.

Dr. Anthony Bass, DMD



Author

Dr. Bass grew up in Salem, Oregon. He went to college in Monmouth, Oregon (now named Western Oregon University) and graduated from Oregon Health Sciences University School of Dentistry in 1982. Since graduation, he has practiced general dentistry in a variety of delivery models including; associateship, solo private practice, large group (FFS, Capitation and Medicaid) and Tribal health clinics. He enjoys distance running, fishing, hunting (archery) and designing, building and flying radio-controlled airplanes. He has been married to his wife, Carole, for 41 years. They have a daughter, Heidi.

Gerry Beauchemin, DT

Author

Gerry is a licensed dental therapist, trained at the National School of Dental Therapy, Canada, and a member of the Saskatchewan Dental Therapist Association. He's been involved in dental care since 1989 in association with volunteer mission organizations in Asia, Africa, and Latin America.

Dr. C. H. Chu, BDS, MDS, PhD

Author

Dr. C H Chu received his Bachelor in Dental Surgery (BDS), Master in Dental Surgery and Doctor of Philosophy (PhD) from The University of Hong Kong. His research interests are dental caries and fluoride therapies. Dr. Chu is experienced in conducting epidemiology surveys, clinical trials, and systematic reviews. Dr. Chu has published many papers in various dental journals and serves as an Associate Editor of BMC Oral Health. He works with Dr. Gao in conducting clinical trials of silver diamine fluoride to arrest early childhood caries of preschool children.

Dr. Harris Contos, DMD, MBA

Author

Harris Contos received his Bachelor Degree in Economics, his dental degree from Tufts University, and his MBA in Health Care Management from Wharton. His wide-ranging health care career began in hospital administration and health care management consulting, but gravitated toward public health issues, including tobacco control, minority health, elder- and young-driver traffic safety, and environmental noise control. As director of a community water fluoridation initiative, he became closely familiar with the issues attending that fundamental subject in dental health, as well as with dental care delivery and policy more broadly, where in his data analysis capacity for a community-based dental health organization led to a "burden of dental disease" study for a county of 230,000, dental workforce development, and his involvement with a Massachusetts statewide coalition on oral health to address unmet dental needs. Insights from these experiences have led him to examine how dental care relates to present reforms in health care, and what the future of dental care would look like given the direction in which health reform is pointing. He sees sizeable inconsistencies, discontinuities and opportunities ahead.

Debby Cosier, BS, MA

Author

Debby Cosier graduated with a degree in pharmacy from the University of Washington in 1975. She then joined the army and worked as a pharmacy officer managing the outpatient pharmacies at a large medical center. While there she received a master's degree in health facilities management. She then went to work in hospital and retail pharmacy until her retirement in 2014.

Dr. Graham Craig, AM, MDS, PhD

Author

Dr. Graham Craig AM, MDS, PhD, FRACDS is currently scientific advisor to Dental Outlook. He was formerly Associate Professor in the Faculty of Dentistry, University of Sydney and subsequently, Director of the Dental Health Foundation at the University of Sydney. His clinical interests have involved the use and evaluation of materials and procedures for minimal intervention dentistry as well as the use of metal fluorides in caries prevention. He has a chemistry background with his PhD being a study of iron fluorides as one of the metal fluorides group.

Following completion of his PhD, Dr. Craig began investigating the potential of silver fluoride in dentistry. In 1978, he and his colleague Keith Powell conducted a ground-breaking minimal intervention program involving the use of silver fluoride in Bourke, western NSW. Australia. It extended over a six -year period and the first 2-year results were published in Community Dentistry and Oral Epidemiology in 1981. The techniques used became the basis of the handbook by Craig and Powell "Expanded atraumatic techniques for the apprehensive child dental patient" published in 2013.

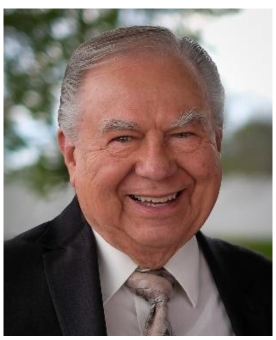
He has published 34 papers in refereed scientific journals throughout the world and has presented over 200 post-graduate courses and lectures.

Marcus L. Duffin, MS, MBA

Author and Editor

Marcus Duffin received his Bachelor Degree in Biochemistry Biophysics from Oregon State University, Masters of Biomedical Science from University of Connecticut Health Center at the John Dempsey Hospital and Masters of Business Administration from Portland State University. During his education, he conducted research focusing on Lou Gehrig's disease and Stem Cells. He is an inventor with patents in the medical and fashion industries. Marcus is the COO of NoDK LLC and Oral Health Outreach. He has focused on developing technologies and international networks that make it possible to treat carious lesions non-surgically at the population level around the world. He has also helped design and implement multiple international treatment programs using Silver Diamine Fluoride.

Dr. Ralph K. Duffin, DDS



Author

Ralph graduated from the University of Washington School of Dentistry in 1958. After three years in the Air Force, he established a practice in general dentistry in Hemet, California and worked there for the next 38 years. Ralph then moved to Grants Pass, Oregon and practiced an additional 20 years. In this time, Ralph was the first dentist to purchase an intra-oral camera and instructed many dentists on the value of its use in oral exams. He made several trips to Vietnam to perform emergency dental procedures for children who had no access to dental treatment. Ralph and his son Steven lectured on the subject of dental practice management in many major dental meeting across the united states in the 1980's and 1990's. Both Ralph and Steven built programs for optimizing economic results by predicting the economic impact of a monetary decision before the commitment was made.

Dr. Steven R. Duffin, DDS

Author and Editor

Steve is a general dentist in Keizer Oregon. His background is in microbiology and public health dentistry with an emphasis on the care of patients with special needs. He was involved in the early development of the dental program serving clients for the Oregon Health Plan and also served as dental director and CEO of Capitol Dental Care for ten years, before returning to private practice in 2005. In recent years, Steve has focused on introducing caries management programs utilizing silver ion products in countries in the developing world. Currently Steve serves as dental director for NODK a medical device R&D company.

Dr. Joshua B. Even, DMD

Author

Joshua B. Even, DMD is the Director of Dental Services for a large FQHC in Austin, Texas. His focus is on proactive, patient-centered dental health care, and developing systems that educate and support the providers within a dental organization of any size. Dr. Even is passionate about the prospect of transforming dental health care by making it more integrated, effective, efficient, and sustainable. He has expertise in dental informatics and electronic dental record design, serving as a bridge between research, data analytics, and operations.

Dr. Jake Felix, MD

Author

After completing medical school at the U. of Wisconsin, Dr. Felix did his internship, residency and fellowship in neonatology at the U. of Rochester, NY. He focused thereafter on neonatology, being Board Certified and becoming the Director of the Division of Neonatology at Sinai Hospital of Baltimore. During that tenure, Dr. Felix developed one of the first neonatal nurse practitioner programs in the U.S. and researched methods for hearing screening in the newborn, both producing multiple publications. He held additional academic appointments at Johns Hopkins School of Medicine and at U. of Maryland.

Dr. Felix next joined the Pediatrics Medical Group at Arnot Ogden Medical Center in Elmira, NY. and served as Medical Director of the neonatal intensive care unit. His community contributions focused on dental health in children, with advocacy for water fluoridation in the region.

Upon retirement to Oregon, Dr. Felix continued to campaign for pediatric dental health as liaison between the Oregon Chapter of the Academy of Pediatrics and the local dental community. He is a committed champion of use of Silver Diamine Fluoride to control caries for all ages.

The personal joys of his life center first on a growing and accomplished family and then on love of extensive international travel. Dr. Felix now enjoys the free time to study all aspects of the universe and nature.

Dr. Kurt Ferré, DDS

Author

Dr. Ferré is a 1976 graduate of Northwestern University Dental School in Chicago. He completed a one-year general practice residency at Rush-Presbyterian-St. Luke's Hospital in Chicago and relocated to Portland in 1980. He retired in December 31, 2008, after a 28 ½ year career with Permanente Dental Associates in Portland.

He is past-president of the Multnomah Dental Society, and he currently serves on the dental advisory board for Medical Teams International and the board of the Oregon Public Health Association.

In 2014, Dr. Ferré was recognized by the Campaign for Dental Health for his fluoridation advocacy and received a Community Water Fluoridation Determination Award. In 2015, he helped co-found the American Fluoridation Society whose mission is to educate and promote fluoridation as sound public health policy and to prevent rollbacks of existing fluoridation programs across the United States.

He is a regular volunteer on a Medical Teams International mobile dental unit and the president of the board as well as the volunteer dental director for the Creston Children's Dental Clinic in SE Portland that serves the low-income children of the Portland Public School System.

Dr. John Frachella, DMD

Author

John is a pediatric dentist in Oregon and Maine with 40+ years' experience in the delivery of dental services in public and private settings. For the first 32 years of his career he was the dental director of a free clinic for indigent children in Bangor, Maine and for ten years served as the director of Asher Dental Services in Wheeler County, Oregon. He also works in private practices across the country, is on staff at OHSU Dental School and lectures for Lutheran Medical College dental residency programs. Since 1999 he has been actively involved in the education, promotion, and protection of fluoridation programs.

He will present new options in the management of caries lesions, especially in certain instances and populations. Over the past decade, Dr. Frachella has been using silver solutions in combination with glass ionomer technology to arrest caries while simultaneously addressing destructive dental cavitation (called **S**ilver **M**odified **A**traumatic **R**estorative **T**echnique - **SMART**). He sees the minimally invasive medical management of caries as a new, historically proven, highly preventive standard of care for the treatment of worldwide populations of children and special needs adults who desperately need dental services the most. Dr. John Frachella is a national leader in the use of SDF and how SDF impacts dental schools and clinical practice.

Dr. Sherry Shiqian Gao, BDS, MSc, PhD

Author

Dr Sherry Shiqian Gao received her Bachelor in Dental Surgery (BDS) from the Huazhong University of Science and Technology. She moved to Hong Kong and was conferred her Master of Science (MSc) in Dental Materials Science and Doctor of Philosophy (PhD) in Dental Public Health from the University of Hong Kong. Dr. Gao's research interests are dental caries and fluoride therapies. She is experienced in conducting epidemiology surveys, clinical trials, and systematic reviews. Dr. Gao has published 20 papers and serves as an Associate Editor of BMC Oral Health. One of her publications 'Clinical trials of silver diamine fluoride in arresting caries among children: a systematic review' published in JDRCTR has been widely cited and used as the reference for setting the American Academy of Pediatric Dentistry guidelines of using silver diamine fluoride in pediatric dentistry.

Dr. Sharon Golightly, EdD, MS

Author

Dr. Sharon Golightly graduated with a Dental Hygiene from Loma Linda University, added a M.S. degree in Occupational Education and a Doctorate (Ed.D.), in Educational Leadership. Has over thirty-five years in dental hygiene education as a professor and Dental Hygiene Program Director and has held several private practice and public health dental hygiene positions. Dr. Golightly is Professor Emeriti at Pierce College Dental Hygiene Program and has received many awards for excellence in Dental Hygiene Education.

Dr. Golightly has established several dental hygiene programs throughout the United States, served as a Dental Hygiene Curriculum and Facilities Consultant for numerous other programs.. Most recently with Pattison Institute with the Kingdom of Saudi Arabia at Qassiam University. In Bolivia, established the Dental Hygiene Curriculum for "Smiles Forever" in 2007 and has since volunteered for several years in Bolivia with the Silver Diamine Project in Villa Tunari. Most recently, presented a poster on the SDF Project in Bolivia in Brisbane, Australia at the International Dental Hygiene Symposium. Dr. Golightly is an active member of the American Dental Hygienists Association(ADHA) and the American Dental Education Association (ADEA).

Dr. Golightly is currently working with "Smiles Forever" to include the Dental Hygiene Educational Program with UPAL (University Private Latin America). Most recently UPAL has sent dental students to work with our dental hygiene graduates and students to work with SDF Program in Villa Tunari.

Dr. Jeremy Horst, DDS, PhD

Author

Dr. Jeremy Horst DDS, PhD is a practicing pediatric dentist and biochemist known for investigating the strengths and limitations of Silver Fluoride therapy and helping to develop SMART fillings. His mission is to reduce suffering from tooth decay by driving the develop of better treatments and preventives. In his teaching and practice he focuses on maximally effective, minimally invasive techniques to stop dental caries and create an easy relationship to dentistry for children and people with special healthcare needs.

Jacqueline A. Juhl, RDH, BS, MS

Author and Editor

Jacqueline is an Oral Health Educator, Clinician, and Community-based Researcher who holds baccalaureate degrees in both Clinical Nutrition (Texas Tech University) and Dental Hygiene (University of Washington) and a double-emphasis Master of Science degree in Dental Hygiene Education and Community and Rural Oral Health (Idaho State University), two short-term fellowships in Dental Education and Care for Persons with Disabilities (DECOD) and a Summer Institute for Dental Clinical Research Certificate of Completion from the University of Washington. She has taught both didactic and clinical dental hygiene, is a member of the IADR, former member of ADEA, ADHA and WSDHA, and President of the Alliance of Dental Hygiene Practitioners. Her major research interests are Equity and Access to Oral Health Care and Delivery, Dental Hygiene Workforce Opportunities, and Global Oral Health and Disease Prevention. She has served with the U.S. State Department on two separate humanitarian missions in nine different countries over a period of five months, has participated in oral health research and education in Ghana and Togo and owner of a direct-access dental hygiene firm, Oral Health Innovations, LLC.

Sandy Kemper, RDH

Author

After 28 some years in the U.S. as a clinical Dental Hygienist, Sandy Kemper founded the Smiles Forever Foundation in Cochabamba Bolivia in 2000. Her first trip to South America was as a participant in a yearly dental humanitarian trip to Cochabamba in 1999. She was taken by the struggle of impoverished woman in Bolivia and the lack of dental prevention for children. The Smiles Forever Foundation was established in 2000 to address these causes. She is one of the recipients of the 2009 RDH Sunstar Award of Distinction.

Sandy was honored to be welcomed to the family of Honorees as the 2018 World of Children Health Award recipient. The Health Award recognizes individuals making extraordinary contributions to children through the fields of health, medicine, or the sciences. The Health Award honors the courageous leader at an annual Awards Ceremony and grants them funds to elevate their work.

Dr. V. Kim Kutsch, DMD

Author

Dr. V. Kim Kutsch received his undergraduate degree from Westminster College in Utah and then completed his DMD at University of Oregon School of Dentistry in 1979. He is an inventor holding numerous patents in dentistry, product consultant, internationally recognized speaker, is past president of the Academy of Laser Dentistry, and the World Congress of Minimally Invasive Dentistry. He also has served on the board of directors for the World Clinical Laser Institute and the American Academy of Cosmetic Dentistry. As an author, Dr. Kutsch has published over 90 articles and abstracts on minimally invasive dentistry, caries risk assessment, digital radiography and other technologies in both dental and medical journals and contributed chapters to several textbooks. He recently coauthored Balance, a textbook on dental decay. He acts as a reviewer for several journals including the Journal of the American Dental Association and Compendium. Dr. Kutsch also serves as CEO of Dental Alliance Holdings LLC, manufacturer of the Carifree system, and Remin Media. As a clinician he is a Graduate, Mentor and Scientific Advisor of Dental Caries at the prestigious Kois Center. Dr. Kutsch maintains a private practice in Albany Oregon.

Dr. Martin MacIntyre, BA, DDS, MPH

Author

- 22 years in US Public Health Service
- Life Diplomate – American Board of Dental Public Health
- General Practice Residency and 3 years of clinical practice
- Taught four-handed dentistry at UOP and dental public health at UCSF
- Director, Project ACORDE – A Consortium on Restorative Dentistry Education
- Development of self-instruction course in restorative dentistry.
- Clinician - National Health Service Corps in Bayview/Hunter's Point, San Francisco
- Dental consultant to Head Start, Region IX
- Reviewed Guam's dental services and introduced sealants.
- 13 years as the Preventive Dentist for Aramco Oil Company in Saudi Arabia
- Federation Dentaire Internationale (FDI) Preventive Dentistry Award.
- Caries control program in public schools
- Caries Risk Assessment Test
- Fluoride urinalysis program
- Maternal and child health program
- Discussed dental caries with all the leading experts in the field between 1984-1997.
- Since 1997 - Retired but still active in preventive dentistry discussions via the Internet.

Dr. Jeanette MacLean, DDS

Author

Dr. Jeanette MacLean is a private practice pediatric dentist from Phoenix, Arizona. She graduated from the University of Southern California School of Dentistry in 2003 and completed her pediatric dental residency in 2005 at Sunrise Children's Hospital through the University of Nevada School of Medicine. She joined Affiliated Children's Dental Specialists in Glendale, Arizona, in 2005, and became an owner in 2007. She is a Diplomate of the American Board of Pediatric Dentistry and Fellow of the American Academy of Pediatric Dentistry. She is an active member of the American Dental Association, holding committee positions at the state level with the Arizona Dental Association. Her clinical research and editorial articles have been published in numerous dental journals and periodicals. She currently lectures on the topic of silver diamine fluoride and SMART restorations, including an online continuing education course offered by Dentaltown, *Silver is the New Black: Improving Your Practice with Silver Diamine Fluoride*. Notably, Dr. MacLean was featured in the New York Times article *A Cavity Fighting Liquid Helps Kids Avoid Dentists' Drills* for her use of Silver Diamine Fluoride. Visit her website www.kidsteethandbraces.com, and YouTube channel, Affiliated Children's Dental Specialists.

Dr. Amal Noureldin, BDS, MSD, MS, PhD

Author

Dr. Amal Noureldin is a dentist, scholar, educator and a dedicated mentor. Currently, a Clinical Associate Professor and Director of Cariology in the Department of Public Health Sciences of College of Dentistry Texas A&M University, specializes in three areas of dentistry, operative dentistry, preventive dentistry and cariology (caries management). She received her dental degree (1993) at the Faculty of Oral and Dental Medicine, Cairo University, Egypt. Dr. Noureldin began her career as a dentist and a faculty with specialist training and Master's degree in Operative Dentistry at Cairo University, Egypt (1998). Earned Masters of Science major Biomaterials (2003) from Baylor College of Dentistry (currently College of Dentistry Texas A&M University, USA) and a PhD degree in Operative dentistry (2007) as a joint supervision between Baylor College of Dentistry and Faculty of oral and Dental Medicine, Cairo University. Currently as Associate Professor her responsibilities include pre-doctoral and postdoctoral didactic and preclinical/clinical Cariology and Prevention teaching. She is the program director of SRG (Summer Research Group) for undergraduate students. Her research interest, which is on dental caries and white spot lesion prevention and treatment, has been supported by Industry contracts. She has published in peer reviewed journals. Dr. Noureldin is the elected President of the American Association for Dental Research (AADR)- Dallas Chapter, and a board member of the community-based health organization American Muslim Women Physician Association AMWPA. Dr. Noureldin was honored with Distinguished Teaching Excellence Award (2016) by Texas A&M College of Dentistry in recognition of her leadership qualities and accomplishments in the undergraduate and graduate levels and honored with Clinical Faculty Research Award in 2019.

Jonalee Cozakos Potter, MHA, BSDH, RDH, EPP

Author

Jonalee has been practicing dental hygiene for over 36 years. I graduated from Weber State College (Ogden Utah) in 1982 with an Associate Degree in Dental Hygiene, graduated from Weber State University (Ogden, Utah) in 2004 with my Bachelor's Degree in Dental Hygiene and graduated in 2010 from Pacific University (Forest Grove, Oregon) with a Master of Health Care Administration degree. I have an Expanded Practice Permit in the State of Oregon which allows me to deliver care outside of a dental office under a Collaborative Agreement with a dentist. I have worked in group practices, private practices, in assisted living/homes, and with the NoDK Team.

Dr. Nayda Apata Rojas

Dr. Nayda Apata Rojas is a Dental Surgeon who graduated from the Universidad Mayor de San Simón (UMSS) in 2013. Before becoming a dentist, she studied in the Dental Hygiene program at Smiles Forever Foundation, graduating in 2006. Post-graduate Education includes Superior Education in 2014 (UMSS), Dental Surgery in 2016 (UPAL), Dental Aesthetics and Oral Rehabilitation in 2018 (UPAL) and is currently taking an online course in oral pathology.

Previously, after completing her studies in the dental hygiene program, she worked as a dental assistant and hygienist in a private clinic for 5 years. After dental school, she carried out her social service in a province of Cochabamba (Mizque). It was there that she confirmed her commitment to provide all the help she could give to the children and people who needed it most, to relieve the ailments they presented. But that was not enough, she realized that the best way to avoid pain was to prevent the occurrence of tooth decay. Therefore she carried out several educational campaigns for tooth brushing and nutrition in schools, kindergartens, and parent meetings in the different communities of the province.

After finishing her social service, she returned to the Smiles Forever Foundation where she studied and worked with children from shelters and the underprivileged. She is currently continuing to work at the Smiles Forever Foundation community clinic as a dentist and Director of the community service clinic. From the year 2014 to the present, she and the Smiles Forever Foundation carry out a program where they apply Silver Diamine Fluoride (SDF) every 6 months to children in Villa Tunari.

In her spare time, she is a member of the Search and Rescue (SAR – BOLIVIA) group of volunteer firemen. She always enjoys helping those who need it.

Dr. Aronita Rosenblatt DDS, MSc, PhD

Author

- Professor of Pediatric Dentistry, University of Pernambuco, Recife, Brazil
- Senior Clinical Investigator, Forsyth Institute, Boston, MA. Harvard School of Dental Medicine and Children's Hospital, Boston
- General Manager for Politics of Higher Education and Research of the State Government of Pernambuco, Secretary of Sciences and Technology, Pernambuco, Brazil.
- Director of International Affairs Pernambuco Funding Agency for Science Technology and Innovation

Dr. Joseph Schwab, PhD

Editor

My primary and secondary education was received in parochial schools in Camden, New Jersey. My college education was at Stonehill College, North Easton, Massachusetts, where I received a B.A. in Philosophy in 1964. Thinking I wanted a career in the clergy, I enrolled at Holy Cross College, Washington, D.C., where I earned a M.A. in Theology in 1967. I then spent a year teaching Theology at St. Peter's Boys' High School in Gloucester, Massachusetts. However, I concluded that my interests were more in line with Psychology than Theology. To this end, I enrolled at the University of Notre Dame, Notre Dame, Indiana, in their doctoral Psychology program in 1968. As I worked towards this degree, I received a M.A. in Counseling in 1970. I continued towards the doctoral degree and received a Ph.D. in Counseling Psychology in 1974.

I began my professional career as the Director of the regional out-patient office in Goshen, Indiana, for the area Community Mental Health Center. Ten years later I left to start my own private practice in Psychology. From 1984 to 1995 I ran an office-based, out-patient practice in Clinical Psychology in South Bend, Indiana. One of the contracts for services I had during those years was with The Family Practice Residency Program of the St. Joseph Regional Medical Center in South Bend, Indiana. My job description included teaching these young physicians the ages and stages of individual and family growth and development which would aid them in their future practice of Family Medicine. The other component of my job description was to teach these young physicians interviewing techniques and "bed side manner."

While I enjoyed this component of my job, I found it far more challenging than with the more “academic” aspects of my work. In any event, the Program excelled and my part-time position as a consultant transitioned to the position of full-time Behavioral Science Faculty member. I was named to that position in 1995 and remained as a faculty member with the residency program until 2000.

Dr. Eyal Simchi, DMD

Author

Dr. Eyal Simchi attended UMDNJ-New Jersey Dental School where he maintained Dean's List throughout his 4 years of dental school. As one of ten siblings, a childhood full of brothers and sisters established his true passion: caring for children. Dr. Simchi went on to complete a two-year pediatric dental residency training program at Maimonides Medical Center. He then continued to advance his specialization by becoming Board Certified.

Having completed his training, he has worked in several prestigious pediatric dental offices before having the opportunity to open Riverfront Pediatric Dentistry in Elmwood Park, NJ.

Dr. Simchi continues advancing his knowledge in Pediatric Dentistry with continuing education classes, incorporating the latest technology and techniques from all over the world.

Dr Simchi is a trailblazer in the field of minimally invasive dentistry. He was one of the first dentists to incorporate hall crowns, LSTR, SDF and SMART into his everyday practice. He is looked up to by his colleagues and constantly asked to consult in this field. He was recently featured in the NY Times article on his use of Silver Diamine Fluoride.

Dr. Simchi prides himself on 'doing dentistry differently.' As a child, Dr Simchi was afraid of the dentist and therefore has a special way of relating to fearful children. Whether it be though magic, jokes, balloon making or song, Dr Simchi ensures that all children leave his office with a smile on their face.

Residing in Passiac, New Jersey with 6 wonderful children and his wife Rochie, who is a certified Labor and Delivery nurse, Dr. Simchi's heart for children beats strong. Nurturing children isn't simply what he does it's who he is.

Dr. Karen Sokal-Gutierrez, MD, MPH

Author

Dr. Karen Sokal-Gutierrez is a physician trained in pediatrics, preventive medicine and public health, with a focus on maternal-child health. She received her BS degree from Yale University, MD from University of California San Francisco, and MPH from University of California Berkeley. She is a Clinical Professor at the University of California, Berkeley School of Public Health teaching medical students, public health graduate students and undergraduate students, and a Fellow of the American Academy of Pediatrics. She has over 30 years of experience working locally and globally as a physician in community health clinics, public health program administrator, consultant to childcare and preschool programs, writer for a parenting website, health care professional educator, researcher, and child health advocate. Over the past 15 years, the focus of her research and advocacy has been early childhood nutrition and oral health in developing countries, including serving as Principal Investigator for studies in El Salvador, Ecuador, Vietnam, Nepal and India.

Elise Tanner RDH, BS

Author

I grew up in the rural town of Nipomo, California, which was about 90% Hispanic. My father was an oral Surgeon and was considered by many of his patients "their dentist" as most could not afford restorative care, they opted for extractions. While working as a teenager in his office, I mostly saw the aftermath of lack of dental services for people who needed it the most. I knew I was just lucky to have a dentist. I started my public heath career in 1976 by joining the Amigos De Las Americas as a sophomore in high school. With them, I went to Blue Fields, Nicaragua and helped vaccinate the children in the barrios surrounding the town. Upon high school graduation, I left home and became a dental assistant for 9 years in the Seattle area. This is where I learned about dental hygienist and the role they play in prevention. In 1992, I graduated from dental hygiene school at Foothill Community College. In 1997, I graduated from the University of Washington's Bachelor's program in Dental Hygiene with a pathway in Oral Health Promotion. I then worked for the University of Washington Oral Health Collaborative for 4 years. This group of dental professionals went to rural areas of Washington state and developed programs to help promote children's oral health with locals at health fairs, schools etc. With help, I developed a program called The Tooth Fairy Academy. This program was a "train the trainer" and worked with high schoolers. In 2001 I and Nancy Alleman RDH, BS developed and implemented "The Tooth Fairies", a school based oral health program. It is currently operating in 38 schools and now serves as group of hygienists. I am currently the sole proprietor. In 2011, Nancy and I went to Cameroon and provided our services to Inkun Village children with a local doctor, Dr Anna Eno Aret. We found no cavities in 161 children, so no services were needed. Currently, I and the fairies have been involved with Sandy Kemper's Smiles forever program in Bolivia and have traveled there five times to help improve the oral health education portion of her program. I have worked in dental offices part time since 1992. In 2014 I learned about Silver Diamine Fluoride and retired from traditional clinical practice to pursue more opportunities with The Tooth Fairies. Currently, we (there's about 14 registered Dental Hygienist with the fairies) want to start providing Silver Diamine Fluoride treatments on children's teeth in schools and inspire anyone who wants to work with us to stop tooth decay anywhere in the world. I look forward to hearing from you. I can be reached at thetoothfairiesrus@gmail.com

Dr. Bethy Turton, BDS, MComDent, PhD


Author

Dr. Bathsheba (Bethy) Turton is a New Zealand trained specialist in Public Health Dentistry. In 2014 Bethy shifted her life to Cambodia in order to establish evidence for best practice in the prevention of dental caries among high risk populations. She has published work on the use of GIC fissure sealants, Fluoride Varnish, and Silver Diamine Fluoride in a Cambodian Environment. Her ongoing research interests are socially accountable models for delivery of oral health care, and on caries-related undernutrition among preschool children. During the last 5-years, Bethy has worked closely with the academic sector, non-governmental organizations, government agencies and the private sector to design interventions and move towards a more coordinated approach to oral health management. Her goals over the next five years are to support the department of Maternal-Child Health Bureau, Cambodia, to implement a program of fluoride varnish application in community health centers (The Cambodia Smile strategy) and to support the school health department to help schools to implement daily tooth-brushing and application of Silver Diamine Fluoride (Level 1 of the Healthy Kids Cambodia strategy).

Kellie Whitcomb RDH, BSDH, MSDH(c)


Author

Kellie Whitcomb graduated in 2009 from Lake Washington Institute of Technology with an AAS in Dental Hygiene. She then completed her degree with a BSDH at Eastern Washington University, where she is currently working on a MSDH degree. With 21 years in dentistry, the last 9 as a dental hygienist, she has worked in general, periodontal, and oral medicine private practice settings. Her most formative years were spent at the University of Washington's Regional Clinical Dental Research Center, where her experiences fostered a passion for public health. She is co-director and clinician of the Tooth Fairies school-based oral health program and direct provider for the elderly in long term care settings through her business, Cornerstone Dental Hygiene Services, LLC. Kellie is an adjunct professor in the dental hygiene program at her alma mater, Lake Washington Institute of Technology.

Dr. Allen Wong, DDS, EdD

Author

- Education: University of the Pacific Arthur A. Dugoni School of Dentistry
- Advanced Clinical Experience and Advanced Education in General Dentistry Certificates
- Fellowship in American Academy of Hospital Dentistry, American College of Dentists, International College of Dentist, Pierre Fauchard Academy, Academy of Dentistry International
- Diplomat American Board Special Care Dentistry (Hospital Dentistry)
- Doctorate, Professional Education and Leadership (EdD)
- Currently teaches at the University of the Pacific Arthur A. Dugoni School of Dentistry in the Department of Dental Practice as well as private practice in San Francisco. He is a member of ADA, CDA and San Francisco Dental Society. Serves as vice chair of SFDS Dental Health Committee. President, National CAMBRA Coalition

Dr. Douglas A. Young DDS, EdD, MS, MBA

Author

Dr. Young is a Professor at the University of the Pacific where he is an active and ardent educator in the field of minimally invasive dentistry and cariology. He was one of the founders of the CAMBRA (caries management by risk assessment) Coalition, ADEA Cariology Section, and the American Academy of Cariology (AAC). Dr. Young served on the ADA Council of Scientific Affairs (2012-2016) and is currently a member of the ADA EBD Leaders network and a cariology consultant for the ADA. Dr. Young has presented at congresses and universities around the world. Dr. Young has been published in numerous peer-reviewed dental journals and textbooks focusing on minimal invasive dentistry, silver fluoride, glass ionomer, and CAMBRA.

How to Use This Book

To the Learner

With this text, we have attempted to provide an historical context of the dental profession and the early scientific relationship between dentistry and medicine including discussion of the “Great Schism” which came to divide both disciplines, and now, led by scientific evidence, to the benefit of those we serve, is resolving. From this ethos, this text proposes to demonstrate through the disciplines of science and public health practice, possibilities to achieve the future of improved oral and systemic health for all. The collected references from all authors in this manuscript represent a rich storehouse of information on this subject.

To the Instructor

Dental Practitioners, including dentists, dental hygienists, or other emerging oral care provider models, are facing rapid and profound changes in oral health care delivery in the 21st Century. Managed Care looms on the horizon. Corporate dentistry has had a measurable impact on how dentistry is practiced in the United States today. Oral health care providers must recognize the impact of the growing numbers of uninsured and underinsured citizens who lack regular and preventive care and who bear the greatest burden of oral diseases. To prepare for the challenges of the changing oral health landscape, practitioners must possess solid knowledge of evidence-based foundational dental, public oral health, and oral-systemic interrelationships as well as solid dental research knowledge. Material in this book is intended for use in a global oral-health curriculum. This book will present information for a wide level of students from a variety of disciplines. A constellation of outstanding experts have contributed chapters and clinical cases to this book which will provide the instructor with a treasure chest of materials to assist faculty in designing and coordinating their courses which will be enhanced by utilizing the online learning materials suggested in this book. The text also includes several links and appendices intended as adjuncts for student presentation preparations in various professional settings.

To the Non-Dental Provider

Historically, the provision of dental services has been siloed to the dental profession. Many global populations experience few opportunities to access oral healthcare. With the advent of effective, simple and safe technologies and products, we can empower other disciplines to expand the scope of access to preventive oral care services, including providers such as physicians, nurses, community health workers, teachers, and possibly others. This text will serve as a comprehensive resource to empower this process.

Introduction

(Dr. Steve Duffin, DDS)

SMART = Silver Modified Atraumatic Restorative Treatment

I would like to address the topic of what science is and what it is not. Confusion about this often leads to conflict and misunderstanding among all of the parties engaged in healthcare activities. The scientific method has evolved since the time of Galileo and has come to be our bedrock of common understanding about the world and our place within it. These are some simple basic steps which outline proper scientific thinking.

1. The observation of some unique phenomenon

2. The development of a hypothesis to explain the observation

3. Tests of the hypotheses to validate or contradict the truth of the hypothesis

4. Creation of a full theory to explain the processes that are contained in the observation and to also make predictions

While numerous scientists have contributed to this manuscript, please allow me to posit that this text does not claim to be science, it is rather a text *about* science. Much of this content involves the observation step in the scientific method. Many credible clinicians and scientists have made similar observations with respect to the treatment of caries with silver ions, fluoride, and glass ionomer cement compounds. This is only the first step of the scientific method. During the 1920's the scientific world experienced a significant disruption with the introduction of Quantum Mechanics by Neils Bohr, Albert Einstein and others. The highly mechanistic worldview established by Isaac Newton was challenged at the microscopic level as a new understanding of atomic phenomenon, complexity and systems theory evolved. *A similar process may be under way presently as dentistry reconsiders the surgical model and embraces oral health from the perspective of wellness through ecological balance.* Some groups of scientists around the world are further along than others in moving toward a robust theory of these observations. Currently, there are a number of high quality randomized clinical trials underway throughout the world which will add further light on our path toward knowledge about this topic. Throughout the text, we will highlight the current gaps in knowledge which exist and remain to be examined. This situation should not be considered to be a weakness or an argument to go backwards in our strategies of patient care. I for one, am grateful that the many topics addressed here are undergoing high level examination and anxiously await the new information which will likely come forth on the topic of caries management.

The purpose of this text is to introduce the reader to what might be called combination therapy using silver ion products, fluorides, and glass ionomer materials. The strategy of providing care to individuals regardless of their location and circumstance, is at the core of this rapidly developing new field in dentistry. Silver compounds have been used by dentists to treat caries since the mid-1800's. The father of modern dental practice, G. V. Black, described in detail a method to arrest tooth decay using silver nitrate in his influential 1908 textbook, *The Pathology of the Hard Tissues of the Teeth* (*Black, 1908*). The rediscovery of silver ion products in caries treatment is both surprising and important, given the prominent place that silver nitrate had in the dental literature from at least 1890 to 1950. For reasons that are not fully known, the practice of using silver nitrate in dentistry declined significantly after the 1950's. In the ensuing decades, dentistry matured as a profession, creating and employing increasingly complex surgical techniques and technologies to treat tooth decay. However, large sections of global populations in the developing world have had no access to these technological advancements. The introduction of Atraumatic Restorative Treatment (ART) methods has begun to address these inequalities and we applaud the efforts of Professor Jo Frencken and colleagues who introduced this approach to dental care (*Frencken, Songpaisan, Phantumvanit, & Pilot, 1994*)

The medical management of caries represents a therapeutic strategy which primarily uses medicine to combat the bacterial pathogens which are central in dental disease. This philosophy is opposed to the traditional approach which focuses on removal of bacteria and diseased tissues using surgical techniques.

In the popular book The Tipping Point, author Malcom Gladwell describes the phenomena of how systems that have remained stable for many years suddenly undergo rapid transformation. It is the opinion of this author and others that the appearance of the new technology silver diamine fluoride into the dental profession, is causing just such a change.

The relatively simple techniques associated with application of the medical approach to controlling tooth decay opens up the possibility that many other provider groups could be engaged in providing care in alternative settings. Examples would be pharmacists, school nurses, physicians, teachers and others. It is the hope of this author that oral health services will take its place embedded in general health systems and thus ending the long-standing problem of the mouth being treated apart from the rest of the body.

Some sections of this text may have the look and feel of having been written specifically for an audience of dentists residing in North America. I apologize for this and hopefully as the reader moves on through the text, it will become obvious that we have a global message that crosses continents, populations, and provider groups.

The following reference is an excellent review of the current knowledge regarding the use of silver diamine fluoride in the control of caries (*Seifo, Cassie, Radford, & Innes, 2019*)

Another challenge that was faced by compiling this text is the fact that we are still in the pioneering stages in the development of the medical management of caries protocols. Many author contributions may have the look and feel of diverse field notes that have been bound together in one textbook. This reality may distract from the traditional look and feel of a mature textbook. However, it is an honest display of the current state of affairs.

References

Black, G. V. (1908). The Pathology of the Hard Tissues of the Teeth (Vol. 1). Chicago: Medico-Dentical Publishing Co.

Frencken, J. E., Songpaisan, Y., Phantumvanit, P. Pilot, T. (1994). An atraumatic restorative treatment (ART) technique: evaluation after one year. International Dental Journal, 44(5), 460–464.

Frencken, J.E.. (2018). The art and science of minimal intervention dentistry and atraumatic restorative treatment. BDJ, 224(12), 922–922. https://doi.org/10.1038/sj.bdj.2018.500

NBCNews.com. (2018, July 9). Treating dental care as an afterthought has dangerous consequences. From NBC News website: https://www.nbcnews.com/think/video/treating-dental-care-as-an-afterthought-has-dangerous-consequences-1273030723978

Seifo, N., Cassie, H., Radford, J. R., & Innes, N. P. T. (2019). Silver diamine fluoride for managing carious lesions: an umbrella review. BMC Oral Health, 19(1). https://doi.org/10.1186/s12903-019-0830-5

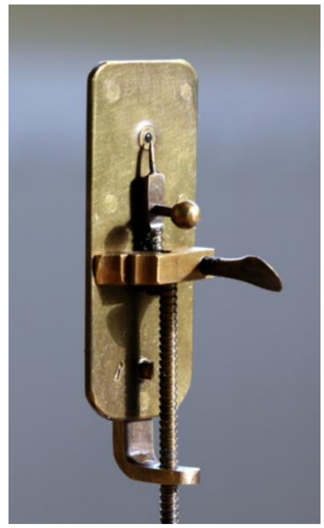
Section One: Historical Development of Medical Management of Caries (MMC)

Medical Microbiology

(Dr. Steve Duffin, DDS)

Antonie van Leeuwenhoek
(1632 – 1723)

Van Leeuwenhoek The First Oral Microbiologist.



One of the first microscopes.

In 1684, Antonie van Leeuwenhoek lived in Delft Holland and was the first person to describe oral bacteria, in a paper which he sent to England's Royal Society. Using a self-crafted lens of great magnification, he observed numerous forms of bacteria present in his own mouth and in the mouths of others. He was able to describe many distinct bacterial types recognizable today. Not satisfied to merely examine and describe the microscopic inhabitants of the mouth, van Leeuwenhoek conducted experiments on himself and others. He tested the viability of oral bacteria when exposed to various fluids. Examples of these experiments include drinking very hot coffee to see if the heat would kill his so-called "animalcules" or little animals. He also rinsed his mouth with various types of wines, liquors and vinegar to determine the effects of these products on the "animalcules". His daily conscientious oral hygiene practices enabled him to serve as a "control" while he examined oral bacteria collected from neighbors who never brushed their teeth, where he noted astonishing numbers and diversity of bacteria in their mouths. In his later years, van Leeuwenhoek removed his own non-viable molar and examined the bacteria found on various tooth surfaces including the roots. This level of observation and experimentation utilizing an innovative magnification device was unprecedented and certainly qualifies van Leeuwenhoek as the father of oral microbiology. Suffering through initial disbelief from the scientific community, van Leeuwenhoek eventually achieved acclaim and many people came from far and wide to peer through his little microscopes. He attained credibility through persistence. From 1680 until 1850 the microscopic world would remain a sideshow curiosity. When Louis Pasteur developed the germ theory of disease, more credibility was given to van Leeuwenhoek's earlier work. However, it was not until Robert Koch extended Pasteur's work, did the world come to realize that most of the major diseases facing mankind throughout history were caused by these "animalcules" first described by van Leeuwenhoek two hundred years earlier (*Paul De Kruif & F González-Crussi, 1996*). Soon after this connection was made, Robert Koch and others set out to identify chemotherapeutic agents that could be used to control the growth of these bacteria.

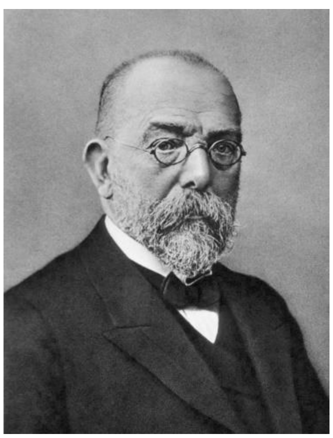
In the 1880's an American dentist working in Koch's Berlin laboratory, W. D. Miller, was experimenting with various chemicals to identify the most effective antimicrobial agents which could be used against the bacterial pathogens of dental disease. His conclusion was that silver nitrate was the most effective and the safest agent tested (*Miller, 1890*)

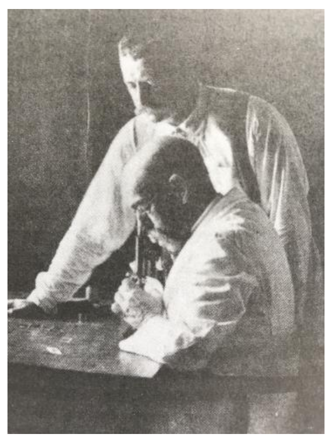
The time from van Leeuwenhoek to Miller covers the journey of discovery from complete ignorance and superstition about the microscopic world and the cause of disease, right up to the point where we began to develop effective chemotherapeutic agents to treat diseases.

One can only wonder why, with the evidence in full view, it took two hundred years to discover the connection between many major human diseases and microscopic bacterial pathogens?
S. Duffin

Robert Koch

(1843-1910)





Robert Koch is the father of modern bacteriology. He elucidated the pathophysiology of numerous diseases such as typhus, tuberculosis and cholera. Koch's contributions raised Pasteur's germ theory of disease onto a practical clinical application level. Perhaps his most famous contribution to science is known as Koch's Postulates. In these simple precepts, Koch outlines the method for identification of the causative agent of a specific disease.

- https://www.nobelprize.org/prizes/medicine/1905/koch/biographical/

Koch's Postulates are the following:

1. The microorganism must be found in abundance in all organisms suffering from the disease, but should not be found in healthy organisms.

2. The microorganism must be isolated from a diseased organism and grown in pure culture.

3. The cultured microorganism should cause disease when introduced into a healthy organism.

4. The microorganism must be re-isolated from the inoculated, diseased experimental host and identified as being identical to the original specific causative agent.

Koch's postulates were powerful tools in the early days of medical microbiology. Little was known about bacterial pathogens or their complex interrelationships and their relationships with the host. Unfortunately, the postulates were often taken as inviolable truths and many future scientists became absorbed in proving the postulates, rather than looking for new ways to describe bacterial based diseases. One early example of this comes from the American dentist, W. D. Miller, who was working in Koch's Berlin laboratory in the 1880's. Miller spent countless hours looking for the specific bacterial pathogen for caries, then gave up in despair having found potentially hundreds of candidates. He almost discovered the complex world of bacterial biofilms, but that would have to wait another 100 years until the medical microbiologist Bill Costerton, published the famous paper "*How Bacteria Stick*" in Scientific American, January 1978. (*Costerton, Geesey, & Cheng, 1978*)

Other early dentists focused on finding the "pathogen" for caries. In 1924 Clark identified a candidate in streptococcus mutans that was a prodigious producer of organic acids in solution and was present in tooth decay (*Clark, 1924*). Scientists went on to study this organism in enormous detail. Strategies were developed to eliminate streptococcus mutans from the biofilm believing that this was the pathway to curing caries. The intractability of this belief continues today, even in the face of evidence that we know nothing whatsoever about the physiology and biochemistry of many of the bacterial species present in human oral biofilms. The modern genomic based tools of molecular biology have demonstrated the presence of many hundreds of species of oral bacteria that **have never been cultured and studied in the laboratory**. Perhaps it is no surprise that we have failed to eliminate caries in the past 160 years. We still have much to learn about the pathophysiology of the disease.

Because Koch's postulates were revolutionary at the time of their development and helped to identify the cause of many of the major plagues of humanity, Koch received the Nobel Prize in physiology and medicine in 1905 for his accomplishments.

Perhaps clinging to these ideas has nonetheless impeded our progress in understanding the complex nature of multispecies biofilm diseases, such as caries and periodontal disease.

References

Clark, J. (1924). On the bacterial factor in the aetiology of dental caries. Journal of Experimental Pathology, 5, 141.

Costerton, J. W., Geesey, G. G., & Cheng, K.-J. (1978). How Bacteria Stick. Scientific American, 238(1), 86–95. https://doi.org/10.1038/scientificamerican0178-86

Ernst Bäumler. (1984). Paul Ehrlich scientist for life. New York Holmes & Meier.

Marsh, P., & Martin, M. (2016). Oral microbiology (6th ed.). Elsevier.

Miller, W. D. (1890). The Micro-Organisms of the Human Mouth.

P Debré. (1998). Louis Pasteur / Louis Pasteur. Baltimore: Johns Hopkins University Press.

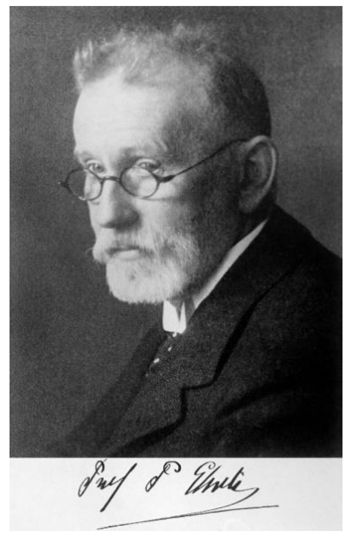
Paul De Kruif, & F González-Crussi. (1996). Microbe hunters. San Diego: Harcourt Brace, Cop.

Medical Chemotherapeutics

(Dr. Steve Duffin, DDS)

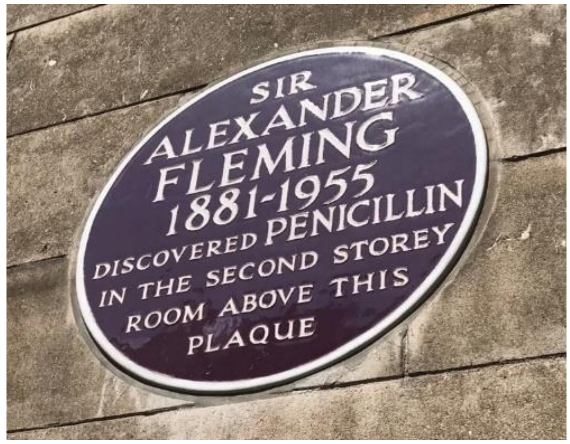
Paul Ehrlich

(1854-1915)



Paul Ehrlich was a physician working alongside the dentist, W. D. Miller in the laboratory of Robert Koch in the 1880's. His specialty was tissue staining and he experimented with many chemical agents to assist with the microscopic examination of tissue samples. This work led to the popular bacterial Gram Stain technique still in use today. Later, working in his own laboratory, he created the first chemotherapeutic agent that was effective against the bacterial pathogen which causes syphilis. This drug came to be called Salvarsan and was commercialized and widely used. For his contributions to science, Ehrlich received the Noble Prize in medicine and physiology in 1908.

Alexander Flemming
(1881-1955)



Sir Alexander Flemming discovered that the presence of a culture plate contaminant, penicillin mold, caused a bacterial growth zone of inhibition on one of his petri dishes in 1928. Rather than throwing the petri dish away and starting over, he asked what could have caused what he was seeing. This observation led to one of the most important scientific discoveries of all time.

Penicillin mold caused zone of inhibition.

Millions of people have survived serious infections with the help of penicillin and other synthetic antibiotics. Dr. Flemming received the Nobel prize in physiology and medicine in 1945 for this discovery. So why do we not have a simple antibiotic-like product that treats caries? This is a very important question and leads us to a better understanding of the complex environment in which oral bacteria inhabit tooth surfaces. As this knowledge accumulates, we

begin to understand how the simple silver ion is so effective in oral therapies that involve their use.

While attending the International Association of Dental Research (IADR) meeting 2018 located in London England, I had the opportunity to visit the Alexander Fleming museum which is located in the very lab where his important discovery was made.

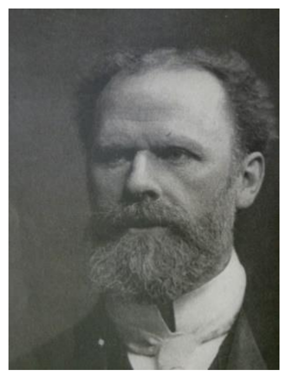
Dental Chemotherapeutics

(Dr. Steve Duffin, DDS)

W. D. Miller

(1853-1907)

W. D. Millers laboratory in the 1880's.



W. D. Miller was an American dentist practicing in Berlin during the 1880's. He was perhaps the first dentist who was formally trained in science and also the author of one of the most important texts of dentistry ever written, (*Miller, 1890*)

In this manuscript, he describes experiments he conducted in a small laboratory in his Berlin dental office, where he proved that tooth decay was caused by a bacterial infection and correlated to the metabolism of carbohydrates which resulted in the production of acid and led to demineralization of tooth structure. This became known as the "**chemoparasitic theory of caries**". Miller articulated the problem of the as yet uncultured bacteria in 1890.

Since these well-known microbes will not grow outside of the mouth, we may suspect that there are other organisms in the mouth, less known or wholly unknown, pathogenic as well as non-pathogenic, which are not cultivable. This of course renders it difficult, if not impossible, to acquire a knowledge of their properties. (*Miller, 1890*)

The powerful tools of modern molecular biology reveal the existence of the organisms alluded to by Miller over one hundred years ago. However, our continuing inability to culture and examine their metabolic properties remains an obstacle to understanding caries as a complex multispecies disease.

Miller also worked in the laboratory of Robert Koch with Paul Ehrlich when the foundations of medical microbiology were being laid. He adopted many of the culture techniques being used in Koch's laboratory for his own experiments with oral bacteria. Miller went on to earn both M.D. and Ph.D. degrees at the university of Berlin as well as becoming a professor at that institution

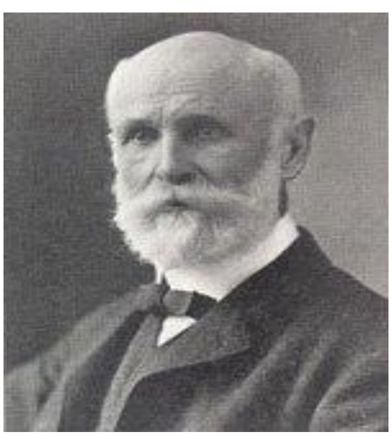
Miller's microscope Univ. of Michigan Syncuse Museum of Dentistry.

- https://www.slideshare.net/umhealthscienceslibraries/willoughby-d-miller-18531907-scientific-pioneer-of-dentistry?next_slideshow=1

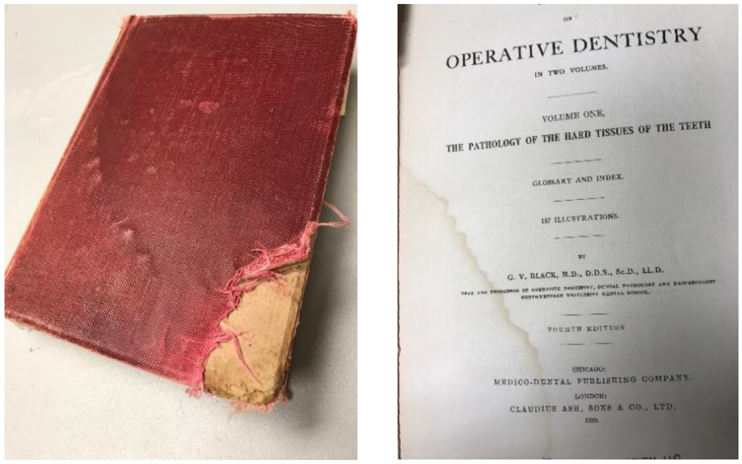
He was offered the position of dean of the dental school at University of Michigan at Ann Arbor Michigan and he was traveling there in 1907 when he died suddenly of appendicitis. Miller was searching in vain for the single pathogen cause for caries following his experiences working in Koch's laboratory. One would have to wonder how dentistry might have evolved in the early 20th century had W. D. Miller been part of that journey.

G. V. Black

(1836-1915)



I remember how excited I was to be starting dental school back in 1979 at Emory University. Each of the 100 students in my class were organized by alphabet and we knew where we would be every day for the next four years. During our orientation, we each received a large

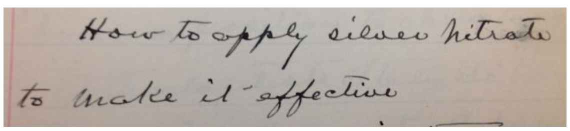


G. V. Black Vol. 1 “The Pathology of the Hard Tissues of the Teeth”

box of books and dental instruments. As I removed the items from my box, I noticed that I had one book by G. V. Black, Volume II on operative dentistry. It never dawned on me that there must have been a Volume I, which was missing from our curriculum for some reason. Over the next couple of years, I learned much about Black’s cavity classification system and his collection of hand instruments for surgically preparing cavities for fillings. Thirty-five years later, while reading a scientific paper about silver diamine fluoride, I noticed a reference to G. V. Black, *The Hard Tissues of The Teeth, Volume I*. I could not find this book anywhere. Eventually, I found a copy for sale on Amazon and ordered it for about two dollars. A week later, I received an old tattered book that looked like it had gone down with the Titanic in 1912. It was from this book that I really discovered the genius that was G. V. Black. More than 100 years ago Dr. Black was carefully studying the microbiology and the pathology of dental caries. His photomicrographs and detailed descriptions of the disease process were stunning. It was in his section on the Management of children’s teeth that I was introduced to the use of silver nitrate to achieve the arrest of caries. Black described in detail how he prepared the silver nitrate solution himself from water and silver nitrate crystals. He then explained the appropriate clinical situations that would benefit from silver nitrate treatment, the precise application protocol, and guidance about how to avoid complications. He provided multiple photographs of treated teeth to demonstrate the effect. For the first time, I began to see G. V. Black as a scientist/clinician who was reaching out through time to help me provide better care for my patients. I had read almost every textbook ever published on the subject of pediatric dentistry and I had a lot of technical knowledge, but nothing shed light on how to care for children in the simple and thoughtful manner described by G. V. Black. Over the next several years, as I gathered enthusiasm for the Medical Management of Caries with silver compounds. (*Schewe, 2009*)

I felt the desire to go to Northwestern University in Chicago and review the archives of G. V. Black that I knew were there. Viewing the handwritten lecture notes by G. V. Black was an inspiration. I found this in one of the thousands of pages located in the archive room.

G. V. Black archive room northwestern university, Chicago, IL.



Afterward, I walked to Lincoln Park where, deservedly, an impressive monument to this great man exists, the founding father of our profession. G. V. Black was largely self-educated. He was drawn to studying the natural world with a practical perspective that served him well as he invented solutions to the many problems that he faced as a frontier dentist (*Schewe, 2009*).

In 1906 G. V. Black traveled to Berlin to meet the other world authority in dentistry of that time, W. D. Miller. While they held differing views on a number of subjects, Black was able to set aside his ego and work side by side with Miller in his Berlin laboratory. No doubt, they probably discussed the use of silver nitrate that Miller had published 16 years earlier. G. V. Black would publish his own perspectives on the subject in 1908. Although G. V. Black is best known for his work in cavity preparation, the sheer volume of material presented in *Volume I* on the *Pathology of the Hard Tissues of the Teeth* is remarkable.

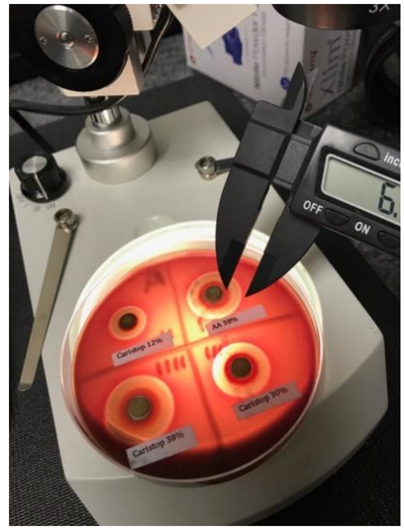
Black went on to be at the center of the discovery of fluoride and its usefulness in the prevention of tooth decay. In 1909, he was invited by Dr. Fredrick McKay to investigate the mysterious dental condition known as Colorado brown stain. Black studied this phenomenon for six years, until his death in 1915. During that period, he and McKay made two crucial discoveries. First, they showed that mottled enamel (as Black referred to the condition) resulted from developmental imperfections in children's teeth. This finding meant residents whose permanent teeth had calcified without developing the stains did not risk having their teeth turn brown. Young children waiting eruption of their secondary teeth, however, were at high risk for developing mottled enamel. **Secondly, they found that teeth afflicted by Colorado Brown Stain were surprisingly and inexplicably resistant to decay.**

G. V. Black statue in Lincoln Park Chicago, IL.

G. V. Black in Colorado Springs, CO.

The two researchers were still a long way from determining the cause of Colorado Brown Stain, but McKay had a theory tucked away in the back of his head. Maybe there was, as some local residents suggested, an ingredient in the local water supply that mottled the teeth? Black was skeptical. McKay, though, was intrigued by this theory's prospects. The mysterious condition later proved to be due to high levels of naturally-occurring fluoride in local water supplies. It is not the intent of this manuscript to review the fascinating history of fluoride and dentistry (*Ole Fejerskov, Ekstrand, & Burt, 1994*). It is remarkable that the use of silver compounds (silver nitrate) and the discovery of fluoride overlapped in the life of the great G. V. Black. Fluoride applied either through addition to water supplies or as topical agents like toothpaste and varnish is largely regarded as the cause of decreased caries prevalence in many countries over the past three decades (*Lagerweij & van Loveren, 2015*).

More than one hundred years later, not much has changed. Sadly, W. D. Miller died prematurely. The opportunity to mend the rift between medicine and dentistry was missed, and this issue continues to be debated today. G. V. Black went on to become famous for his classification of cavity preparations. Like G. V. Black, and Miller before him, I have a microbiology lab associated with my dental practice where biofilm behavior and antimicrobial activity is measured.



Dr. Duffins Lab.

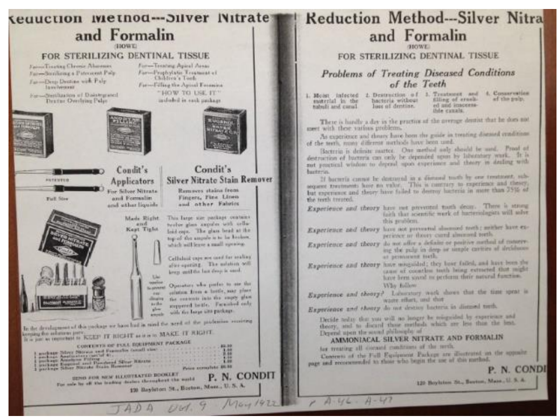
It seems the more we think we know about caries, the less we understand about this complex disease. Using the tools of modern molecular biology, more than 700 species of bacteria have been found living in the human mouth. Less than one half of the species have ever been successfully cultured in the laboratory. So, one hundred years after the groundbreaking work of Miller and Black, we still have much to learn about the disease however, we have silver ion compounds to arrest caries, and unlike those early pioneers, we understand more about how these substances work in the processes of arresting caries.

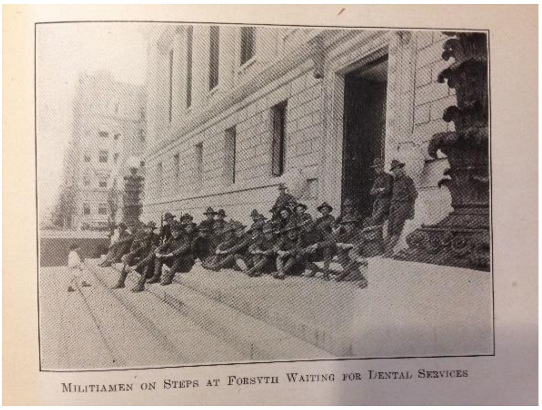
Percy Howe
(1893-1977)

Percy Howe was the first Research Director at the Forsyth Institute in Boston Massachusetts. In 1917 Dr. Howe published the most highly regarded dental scientific paper of his era in *Dental Cosmos* (*Howe, 1917, pp. 891–904*). In this important contribution to the dental literature, another description for arresting tooth decay using silver nitrate is described.

Between 1920 and 1950, this technique became so popular that the silver compound which was used came to be known as *Howe's Solution*. During 1928-29, Dr. Howe served as the president of the American Dental association.

Thousands of children who were treated at the Institute every year received the silver nitrate method and this was carefully documented in the Forsyth annual records. Additionally, Army soldiers leaving for WWI were also treated with Howe's solution.

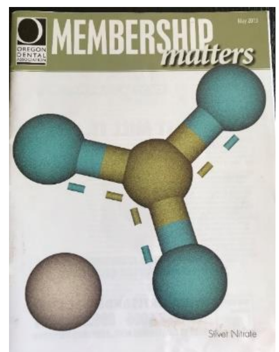




Children and WW1 soldiers waiting for silver nitrate treatment at the Forsyth Institute in Boston, MA.

Why then, did treatment with silver nitrate fall out of fashion after 1950?

Soon after a 1947 Ann Arbor dental conference on caries control and prevention, Dr. Percy Howe an ardent advocate of silver nitrate, passed away. After his death, it seemed that Howe's solution also passed away. The opportunity to implement the effects of silver nitrate and sodium fluoride in a sequential combination therapy was missed. Water fluoridation became the new paradigm for caries control. Soon fluoride even appeared in toothpaste. The success of the fluoride era cannot be overstated. By the 1970's, caries rates were plummeting in the United States. There were rumors of a new vaccine for tooth decay that would eliminate treating tooth decay with a drill. As yet, there is no vaccine, and none is likely in the near future due to the multispecies nature of the disease. Sixty-seven years after the Ann Arbor conference, dental decay is endemic and epidemic on a global scale. How different might things be today, if out of that conference the possibility of using silver nitrate and sodium fluoride together in a sequential combination therapy had emerged instead of merely comparing the two materials.



A flurry of controversy erupted when the Oregon Dental Association dedicated it's 2013 journal to the subject of silver nitrate. One might have thought that it was something new and radical.

References

Berg, J. H., & Slayton, R. L. (2016). Early childhood oral health. (p. 294) Hoboken, New Jersey: John Wiley & Sons, Inc

Howe, P. R., & Howe, P. R. (1917). A method of sterilizing and at the same time impregnating with a metal, affected dentinal tissue (Vol. 59, pp. 891–904). Philadelphia: S S White Dental Manufacturing Company.

Lagerweij, M. D., & van Loveren, C. (2015). Declining Caries Trends: Are We Satisfied? Current Oral Health Reports, 2(4), 212–217. https://doi.org/10.1007/s40496-015-0064-9

Marsh, P., & Martin, M. (2016). Oral microbiology (6th ed.). (p. 17) Elsevier.

Miller, W. D. (1890). The Micro-Organisms of the Human Mouth.

Miller, W. D. (1890). The Micro-Organisms of the Human Mouth. (p. 257)

Ole Fejerskov, Ekstrand, J., & Burt, B. A. (1994). Fluoride in dentistry (2nd ed.). Copenhagen: Munksgaard International Publishers

Schewe, E. F. (2009). G. V. Black by E. F. Schewe. from Wustl.edu website: http://beckerexhibits.wustl.edu/dental/articles/Black_Schewe.html

Oral Microbiology

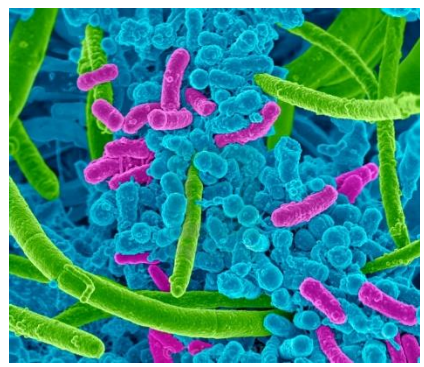
(Dr. Steve Duffin, DDS)

Bill Costerton

(1934-2012)

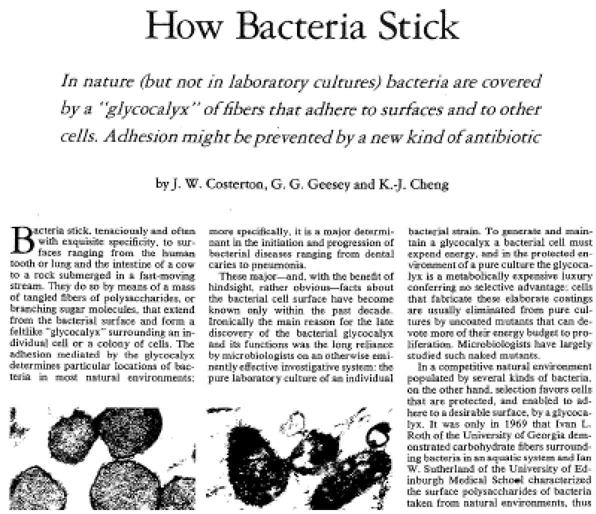
Bill Costerton was a medical microbiologist who wrote a seminal paper "How Bacteria Stick" in January of 1978 and was published in *Scientific American*. (*Costerton, Geesey, & Cheng, 1978*) It was in this paper that the concept of a complex multispecies biofilm was articulated. The model that he used to describe this phenomenon was dental plaque.

His book, *The Biofilm Primer*, published in 2007, vastly expanded our understanding of complex microbial interrelationships (*Costerton, 2007*). Costerton came to the remarkable conclusion that medical microbiologists had been studying bacteria under artificial invitro laboratory conditions, rather than actual in vivo conditions, since the time of Pasteur and Koch. While walking through the streams surrounding his lab at Bozeman Montana, he realized that the slippery substance on river rocks was a film of bacteria. This discovery caused him to wonder if the artificial conditions of culturing bacteria in the laboratory might have caused us to have a misguided understanding of their in-vivo physiology. This was a huge step forward and a shocking realization that 100 years of microbiology might *just be wrong*. He coined the metaphor "perhaps it is time to reboot the hard drive" when thinking about microbiology.



Oral biofilm.

The tooth surfaces represent the single non-shedding surface of the human body where bacteria are present. Therefore, bacteria may remain in place for extended periods of time and have the opportunity to cause mischief such as that shown in the image below.



How Bacteria Stick

In nature (but not in laboratory cultures) bacteria are covered by a "glycocalyx" of fibers that adhere to surfaces and to other cells. Adhesion might be prevented by a new kind of antibiotic

by J. W. Costerton, G. G. Geesey and K.-J. Cheng

Bacteria stick, tenaciously and often with exquisite specificity, to surfaces ranging from the human tooth or lung and the intestine of a cow to a rock submerged in a fast-moving stream. They do so by means of a mass of tangled fibers of polysaccharides, or branching sugar molecules, that extend from the bacterial surface and form a feltlike "glycocalyx" surrounding an individual cell or a colony of cells. The adhesion mediated by the glycocalyx determines particular locations of bacteria in most natural environments; more specifically, it is a major determinant in the initiation and progression of bacterial diseases ranging from dental caries to pneumonia.

These major—and, with the benefit of hindsight, rather obvious—facts about the bacterial cell surface have become known only within the past decade. Ironically the main reason for the late discovery of the bacterial glycocalyx and its functions was the long reliance by microbiologists on an otherwise eminently effective investigative system: the pure laboratory culture of an individual bacterial strain. To generate and maintain a glycocalyx a bacterial cell must expend energy, and in the protected environment of a pure culture the glycocalyx is a metabolically expensive luxury conferring no selective advantage; cells that fabricate these elaborate coatings are usually eliminated from pure cultures by uncoated mutants that can devote more of their energy budget to proliferation. Microbiologists have largely studied such naked mutants.

In a competitive natural environment populated by several kinds of bacteria, on the other hand, selection favors cells that are protected, and enabled to adhere to a desirable surface, by a glycocalyx. It was only in 1969 that Ivan L. Roth of the University of Georgia demonstrated carbohydrate fibers surrounding bacteria in an aquatic system and Ian W. Sutherland of the University of Edinburgh Medical School characterized the surface polysaccharides of bacteria taken from natural environments, thus

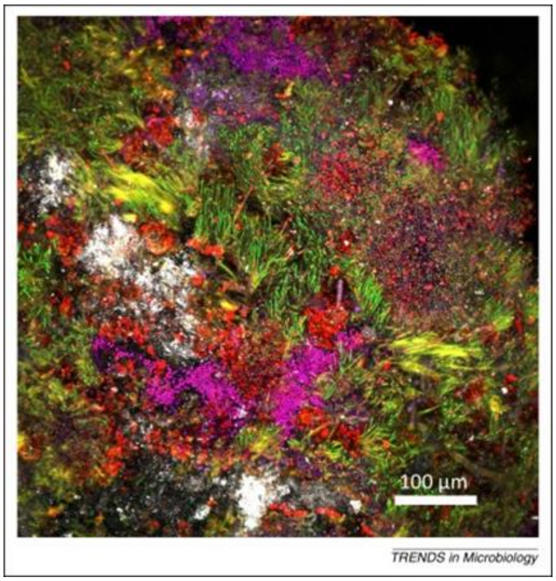
Link to Coserton biofilm lecture

- http://www.mmclibrary.com/Biofilm.html

Philip Marsh

In 2003, microbiologist Philip Marsh published his landmark paper, *"Are Dental Diseases Examples of Ecological Catastrophes?"* (*Marsh & Martin, 2016*) Using a sophisticated laboratory oral biofilm model, Marsh showed that both the composition and physiology of oral bacterial biofilms change under varying conditions of pH. Repeated conditions of low pH select for the bacteria implicated in caries while simultaneously inhibiting the growth of beneficial species found in health. While this is a rather simplistic study model as compared to the vastly more complex in vivo oral environment, the controlled conditions afforded by the model opened the door for further investigation into the complex interactions that occur in multispecies biofilms over time. His work has come to be known as the "ecological plaque hypothesis."

Modern imaging technologies have revealed that the oral biofilm which inhabits enamel tooth surfaces is incredibly complex in composition and physiology.

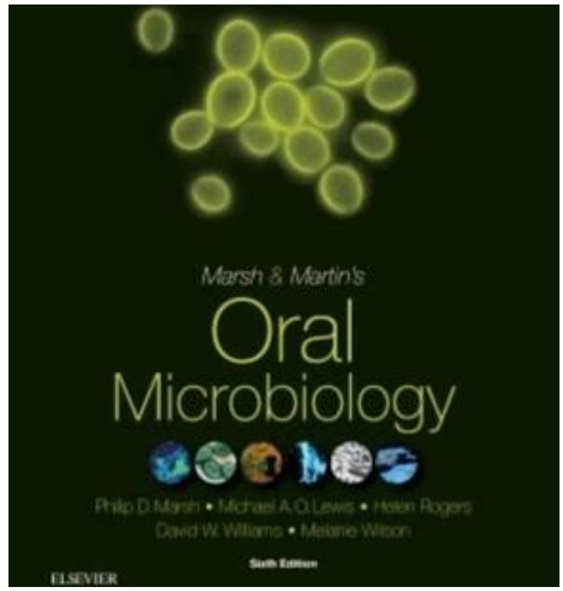


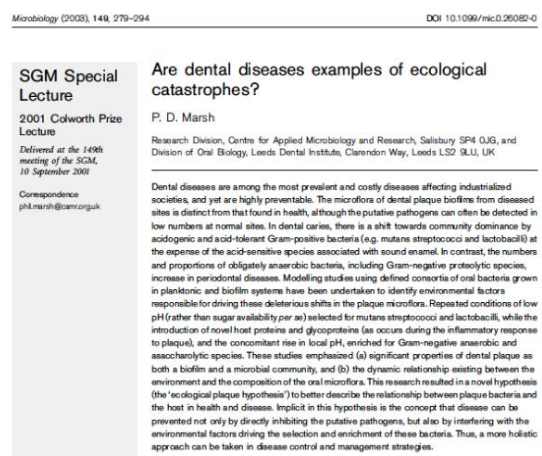
Philip Marsh is also the author of the popular text, *Oral Microbiology*, now in it' 6th edition. (*Marsh & Martin, 2016*) Gene sharing and gene expression are coordinated in a massively complex system that exhibits both competitive and cooperative roles for each individual organism and the biofilm as a super-organism.

Link to Marsh biofilm lecture

- http://www.mmclibrary.com/Biofilm.html

Prior to 1979 and in the absence of the understanding of biofilm physiology, the surgical management of dental caries predominated. More recently, oral health professionals are beginning to challenge the surgical model of caries treatment. The Medical Management of Caries employs the understanding of bacterial physiology and utilizes effective anti-microbial and chemotherapeutic agents to manage the causative organisms of dental disease. What Marsh demonstrated was that a disruption in the homeostasis of the oral biofilm community resulted in a bacterial "ecologic catastrophe" which then manifested as oral disease.





Microbiology (2003), **149**, 279–294 DOI 10.1099/mic.0.26082-0

SGM Special Lecture

2001 Colworth Prize Lecture

Delivered at the 149th meeting of the SGM, 10 September 2001

Correspondence
phil.marsh@camr.org.uk

Are dental diseases examples of ecological catastrophes?

P. D. Marsh

Research Division, Centre for Applied Microbiology and Research, Salisbury SP4 0JG, and Division of Oral Biology, Leeds Dental Institute, Clarendon Way, Leeds LS2 9LU, UK

Dental diseases are among the most prevalent and costly diseases affecting industrialized societies, and yet are highly preventable. The microflora of dental plaque biofilms from diseased sites is distinct from that found in health, although the putative pathogens can often be detected in low numbers at normal sites. In dental caries, there is a shift towards community dominance by acidogenic and acid-tolerant Gram-positive bacteria (e.g. mutans streptococci and lactobacilli) at the expense of the acid-sensitive species associated with sound enamel. In contrast, the numbers and proportions of obligately anaerobic bacteria, including Gram-negative proteolytic species, increase in periodontal diseases. Modelling studies using defined consortia of oral bacteria grown in planktonic and biofilm systems have been undertaken to identify environmental factors responsible for driving these deleterious shifts in the plaque microflora. Repeated conditions of low pH (rather than sugar availability *per se*) selected for mutans streptococci and lactobacilli, while the introduction of novel host proteins and glycoproteins (as occurs during the inflammatory response to plaque), and the concomitant rise in local pH, enriched for Gram-negative anaerobic and asaccharolytic species. These studies emphasized (a) significant properties of dental plaque as both a biofilm and a microbial community, and (b) the dynamic relationship existing between the environment and the composition of the oral microflora. This research resulted in a novel hypothesis (the 'ecological plaque hypothesis') to better describe the relationship between plaque bacteria and the host in health and disease. Implicit in this hypothesis is the concept that disease can be prevented not only by directly inhibiting the putative pathogens, but also by interfering with the environmental factors driving the selection and enrichment of these bacteria. Thus, a more holistic approach can be taken in disease control and management strategies.

Additionally, the work of Mertz-Fairhurst, demonstrated that lesion progression could be prevented by bacterial nutrient deprivation. As noted in the abstract below, frank decay was left in place and sealed over, then tracked for ten years. These findings indicated that when the bacteria are isolated from a nutrient source by therapeutic sealing, the decay became arrested.

This challenges the established belief that all decay must be physically removed from the tooth prior to the placement of a restoration.

Non-surgical Intervention and Treatment to Starve Biofilm

"Ultraconservative and cariostatic sealed restorations: results at year 10." *(Mertz-fairhurst et al., 1998)* Below is the abstract pulled from this publication.

Abstract

"Changes in restorative techniques and the development of newer restorative materials have allowed for the introduction of more conservative cavity preparations. This 10-year study evaluated bonded and sealed composite restorations placed directly over frank cavitated lesions extending into dentin vs. sealed conservative amalgam restorations and conventional unsealed amalgam restorations. The results indicate that both types of sealed restorations exhibited superior clinical performance and longevity compared with unsealed amalgam restorations. Also, the bonded and sealed composite restorations placed over the frank cavitated lesions arrested the clinical progress of these lesions for 10 years."

References

Costerton, J. W. (2007). Biofilm primer, The (9783540680215) MPE-0154. Springer.

Costerton, J. W., Geesey, G. G., & Cheng, K.-J. (1978a). How Bacteria Stick. Scientific American, 238(1), 86–95. https://doi.org/10.1038/scientificamerican0178-86

Gao, S. S., Zhao, I. S., Hiraishi, N., Duangthip, D., Mei, M. L., Lo, E. C. M., & Chu, C. H. (2016). Clinical Trials of Silver Diamine Fluoride in Arresting Caries among Children. JDR Clinical & Translational Research, 1(3), 201–210. https://doi.org/10.1177/2380084416661474

Gurenlian, J. R. (2007). The Role of Dental Plaque Biofilm in Oral Health. Journal of Dental Hygiene, 81(suppl 1), 116.

Hiraishi, N., Yiu, C. K. Y., King, N. M., Tagami, J., & Tay, F. R. (2010). Antimicrobial Efficacy of 3.8% Silver Diamine Fluoride and Its Effect on Root Dentin. Journal of Endodontics, 36(6), 1026–1029. https://doi.org/10.1016/j.joen.2010.02.029

Marsh, P., & Martin, M. (2016). Oral microbiology (6th ed.). Elsevier.

Marsh, P. D. (2003). Are dental diseases examples of ecological catastrophes? Microbiology, 149(2), 279–294. https://doi.org/10.1099/mic.0.26082-0

Mertz-fairhurst, e. J., curtis, j. W., ergle, j. W., rueggeberg, f. A., & adair, s. M. (1998). Ultraconservative and cariostatic sealed restorations: results at year 10. The journal of the american dental association, 129(1), 55–66. Https://doi.org/10.14219/jada.archive.1998.0022

Niederman, R., Huang, S. S., Trescher, A.-L., & Listl, S. (2017). Getting the Incentives Right: Improving Oral Health Equity With Universal School-Based Caries Prevention. American Journal of Public Health, 107(S1), S50–S55. https://doi.org/10.2105/ajph.2016.303614

Section Two: Modern Scientific Foundation for Medical Management of Caries

Introduction

(Dr. Steve Duffin, DDS)

The following section will introduce the reader to some of the powerful tools of molecular biology and how these technologies are being employed in understanding the processes taking place when silver, fluoride and glass ionomer materials are being used in clinical practice. This will include both the perspective of the effects on human tissues and on the oral bacteria. A more comprehensive guide to the field of molecular biology should be sought elsewhere.

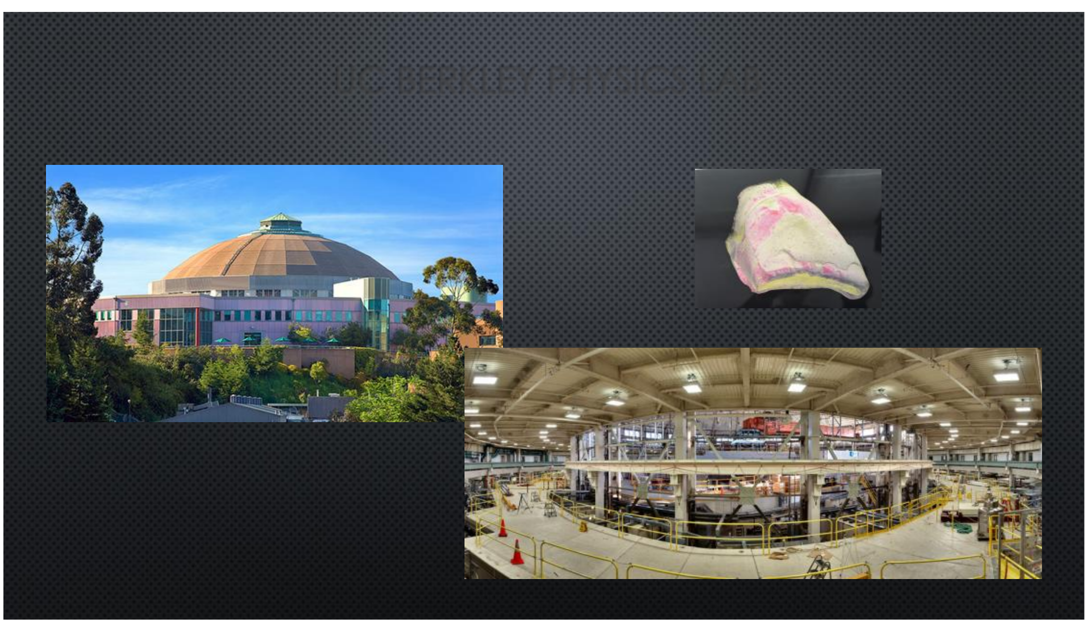
The microscopes of Van Leeuwenhoek opened our understanding of a previously invisible world, which led to many advances in science and technology benefiting mankind. As the disciplines of chemistry and physics developed, more powerful tools became available to look more deeply into the biological world. Beyond the outlines of single cells and into the workings of intracellular metabolism. Perhaps the pinnacle of this chapter in history was the discovery of DNA, the code of life in the 1950's. It is instructive to touch on some of these technologies and how they assist in the understanding and treatment of dental diseases.

Caries (tooth decay) and conditions of the gingiva and supporting structures (gingivitis and periodontitis) are largely a result of interactions between oral bacteria and human tissues. These processes can be examined with the sophisticated tools of molecular biology.

We can divide this section into two large categories.

1. The effects of SDF application on tooth structure

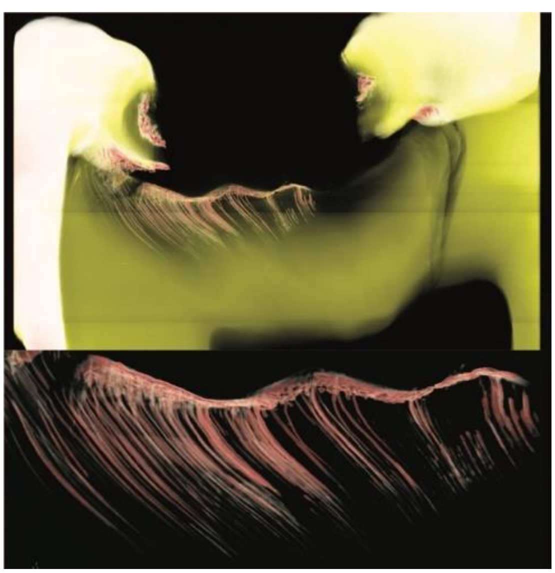
2. The effect of SDF on bacterial physiology



Advanced Light Source Laboratory at UC Berkeley.

The effect of fluoride on tooth structure has been examined for many years. Essentially the presence of fluoride and tooth enamel results in the conversion of hydroxyapatite into fluorapatite, a mineral which is more resistant to acid challenge in the mouth. The development of x-ray crystallography enabled scientists to see beyond the limits of optical microscopes and to discover information about chemical changes at the atomic level. The role of silver ion when exposed to tooth structure has been less well studied. Early investigations using optical microscopes revealed evidence that silver ions were present in the interprismatic spaces of enamel after placement (Geoff Knight personal communication.) More recently, the work of Dr's. Jong Seto and Jeremy Horst, at the Advanced Light Source Lab at the University of California at Berkeley, has resulted in very high-resolution images which show silver atoms in intimate relationship with treated tooth structure.

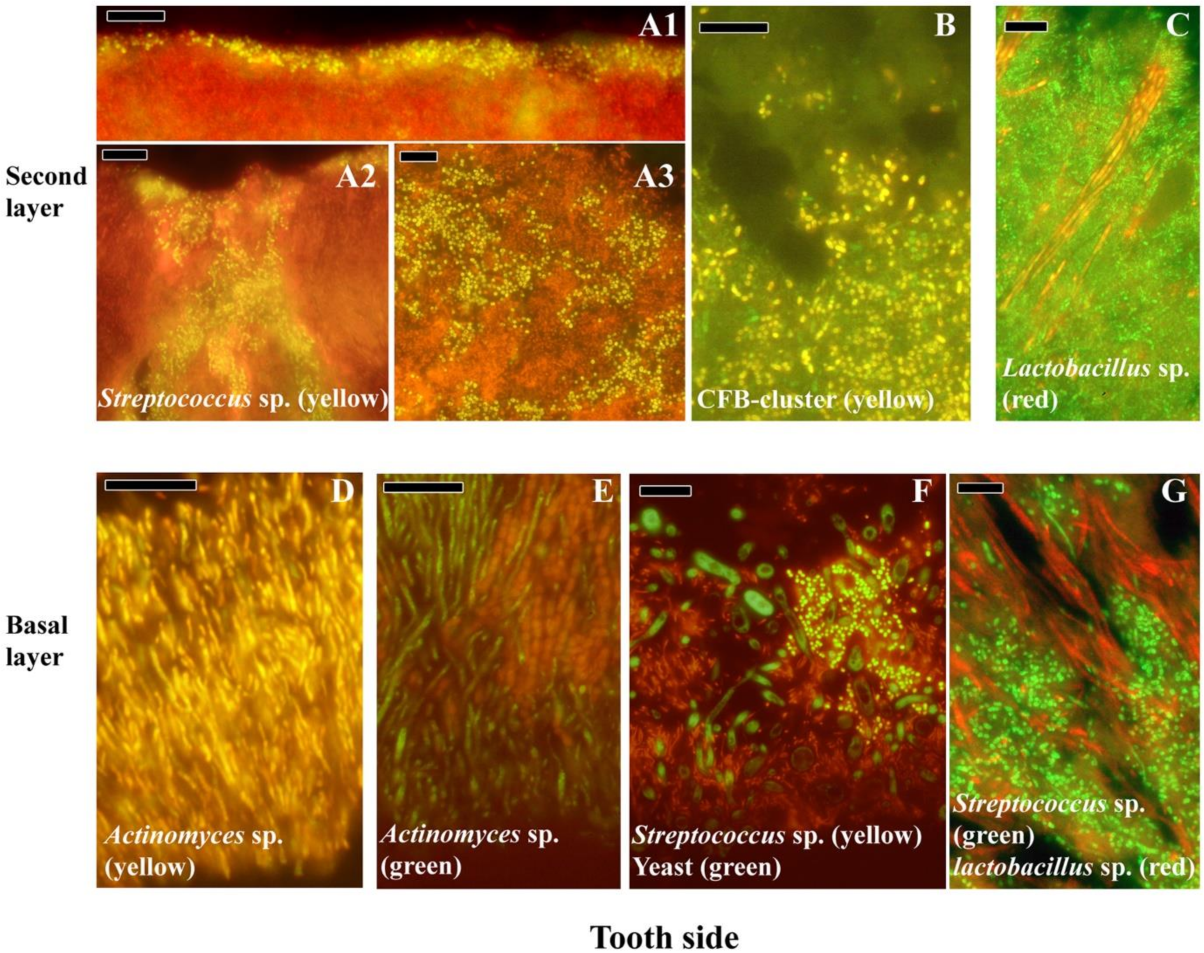
Warning: DO NOT TRY THIS AT HOME!



The image to the left is an exfoliated primary molar which had been previously treated with silver diamine fluoride. Note the presence of silver which has penetrated and occluded the open dentinal tubules of this sample. Silver is seen as pink in this example.

The above image is produced from the exfoliated (age six) maxillary central incisor tooth from the "Claire" case report described elsewhere in this text. Please note that the silver which was placed when she was one year old is seen in pink. In addition, it is possible to visualize remnants of the glass ionomer cement which was placed by Dr. Frachella, to cover the "silver scar" when Claire was age four and about to enter school. Please refer to the chapter by Dr. Frachella.

The image below is of Fluorescent in situ hybridization (FISH), which is a powerful tool for multi species analysis of complex biofilm structures. Knowledge of FISH helps the investigator to better assess the three-dimensional structure and composition of oral biofilms.



Caries Chemotherapeutic Products and the Time Period of Their Use

(Dr. Steve Duffin, DDS)

Silver Agents

The search for an effective antimicrobial agent in the treatment of caries takes us back in time to the period just after Luis Pasteur's discoveries collectively known as the "Germ Theory of Disease" (1850-1880) (*P Debré, 1998*). W. D. Miller's 1890 magnum opus, *The Micro-Organisms of the Human Mouth* presents the chemo-parasitic theory of caries which described tooth decay as the process of bacterial metabolism of carbohydrates resulting in acid production (*P Debré, 1998*). Miller was highly influenced by the groundbreaking work in microbiology being conducted in the laboratory of Berlin professor Robert Koch. Koch's Postulates showed that different human diseases were the result of infections by specific micro-organisms. Miller sought to identify the unique bacteria that cause tooth decay, but due to the limitations of technology at the time, he was unsuccessful. In the course of his investigations, he tried a variety of known antiseptic solutions to determine their effect on oral bacteria. After testing many candidate chemicals, he found that the most effective antimicrobial agent of the time was bichloride of mercury. The second most effective was silver nitrate. Miller understood that bichloride of mercury was toxic and warned against its use. He supported the further investigation of silver nitrate. Miller anticipated the future development of some kinds of tooth filling materials that would contain antimicrobial properties as well as restorative features. Sadly, Miller passed away in 1907 from acute appendicitis while traveling from Berlin to Ann Arbor to become the dean of the University of Michigan School of Dentistry. G. V. Black (1908) and Percy Howe (1917), among others, continued this work to refine the use of silver nitrate as a safe and effective antimicrobial agent in the treatment of caries. In the first half of the 20th century, little was known about the mode of action of silver nitrate in caries arrest. During a historic conference held at the University of Michigan at Ann Arbor in 1947, dental experts argued the merits of silver nitrate versus the new fluoride-based products (*Duffin, 2019*). An excellent example of a debate over competing paradigms in dentistry occurred at that 1947 conference. The title of the event was *"Dental Caries Mechanism and Present Control Techniques,"* and was sponsored by the W.K. Kellogg Foundation. Dr. Kenneth Easlick, the grandfather of dental public health, organized the presentations. The proceedings were published in the *Journal of Dental Research*. The most prominent dental experts in America at the time were in attendance: Dr. Basil Bibby, Director of the Eastman Dental Center; Dr. John Knutson, Chief of the Dental Section US Public Health Service; Dr. Robert Stephan, National Institute of Health; Dr. Helmut Zander, Tufts College of Dentistry; Dr. Phillip Jay, Professor of Dentistry, University of Michigan; and Dr. Russell Bunting, Professor of Dentistry, University of Michigan. One of the central themes of this conference was focused on the risks and benefits of the historical paradigm: *silver nitrate to control caries* versus an emerging paradigm *sodium fluoride*. A robust dialogue between the participants was transcribed verbatim and, even today provides, us with an insightful view into the process for examining scientific evidence and attempting to reach a consensus. The brief insert below is a direct transcription of the conference debate:

Dr. Phillip Jay: *"The role of silver nitrate in caries control has been discussed for years. Among us here, Olin Hoffman of Iowa thinks it works and John Knutson of Washington thinks it doesn't. Dr. Zander, whose job it was to render a verdict, 'isn't saying' He is of the opinion that silver nitrate could be given a fairer trial."*

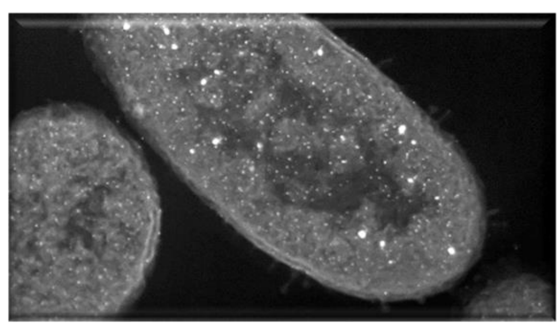
Dr. Hulmut Zander: *"There are many public health workers here; perhaps one of them will go home with the possibilities of silver nitrate in mind as well as the actualities of sodium fluoride."*

Dr. Russell Bunting: *"I can see so much substantial progress as has been reported at this conference and the zeal and true scientific approach with which the investigators have been attacking the problem, I have real hope that even in my lifetime this great question be solved and that the boon of freedom from dental caries be vouchsafed to mankind through dental research. I wish you Godspeed."*

Soon after this conference, Dr. Percy Howe, an ardent advocate of silver nitrate, passed away. After his death, it seemed that Howe's Solution also passed away. The opportunity to implement the effects of silver nitrate and sodium fluoride in a sequential combination therapy was overlooked. Water fluoridation became the new paradigm for caries control. Soon fluoride even appeared in toothpastes. More recently, fluoride is now found in mouthwashes and dental floss. The success of the fluoride paradigm cannot be overstated. By the 1970's, caries rates were plummeting in the United States. Some clinicians speculate that a new vaccine for tooth decay that would eliminate treating tooth decay with a drill. We have yet to develop such a caries vaccine, but some may posit that we may have, at least, a *silver bullet*.

Seventy years after the 1947 Ann Arbor conference, dental decay is globally both pandemic and epidemic. How different might things be today, if out of that conference, the possibility of using silver nitrate and sodium fluoride together in a combination therapy had emerged instead of merely comparing the two? A paper describing the sequential use of silver nitrate and sodium fluoride varnish was published in the November 2012 edition of the Journal of the California Dental Association (CDA Journal) by this author (*Duffin, 2012*). Subsequent issues in the Journal of the American Dental Association (JADA) and the CDA Journal have been published, continuing the discussion of silver ion use in dentistry.

Recently, numerous papers have been published about the action of silver ions in bacterial physiology. We now understand that the principle manner in which silver compounds participate in caries arrest is via free silver ion interaction with bacterial cytoplasm and



Silver present in bacterial cytoplasm.

inactivation of vital cell structures and functions. (*Mei, Lo, & Chu, 2018*) (*Russell & Hugo, 1994*)
We also now know a great deal more about the role of fluoride in preventing and controlling caries. This function is largely via the conversion of enamel hydroxyapatite to fluorapatite in a process known as the *caries balance*. The work of John Featherstone contributed greatly to this breakthrough in understanding (*Featherstone, 2006*).

States Food and Drug Administration (US FDA). As of April 2015, the product, *Advantage Arrest*® (38% silver diamine fluoride) was cleared to market as a desensitization agent and cavity liner by the FDA and is available and marketed by Elevate Oral Care. Recently, interest has been re-established regarding silver fluoride efficacy in caries arrest. This development is likely to result in many more studies about how to optimize treatment protocols of this product for use in the

Silver Nitrate early 1900's.

Saforide SDF 1970's.

Advantage Arrest SDF.

During the 1960's, scientists in Japan realizing the benefits of silver nitrate and sodium fluoride, created a new compound, silver fluoride. Over the next 30 years silver fluoride was used in countries around the world and was found to be effective in arresting tooth decay. However, during the 1990s, some controversial studies raised concerns regarding the use of silver fluoride in caries treatment (*Gotjamanos, 1997*). This concern involved the amount of fluoride in the product. These studies may have contributed to its less frequent use in caries treatment and *these concerns were never clinically demonstrated (author opinion).*

Today, there exists a plethora of high-quality scientific papers about the use of silver fluoride in controlling tooth decay in high risk populations. Until recently, the importation and marketing of silver fluoride products in the United States was not supported by the United

USA and elsewhere. The reader is directed to this excellent video presentation by Dr. Jeremy Horst and Dr. Elleni Ellenikiotis speaking for the University of California at San Francisco Caries Arrest Committee.

- https://youtu.be/zUAJkqcItco

An additional presentation by Dr. Mike Shirtcliff and Dr. Peter Milgrom about the journey to FDA clearance of SDF is available online at the following site.

- http://www.mmclibrary.com/SDF_-_FDA_Status.html

In 2015, the Oregon Board of Dentistry recognized silver diamine fluoride as another form of topical fluoride, similar to sodium fluoride, stannous fluoride, and acidulated phosphate fluoride. This precedent setting decision opens up the use of this product by **dental hygienists** and **other healthcare providers**. A new era in the treatment of caries for high risk and low access to care populations is now before us.

Chlorhexidine

Chlorhexidine (Chx) is often used as an active ingredient in mouthwash designed to reduce gingivitis, dental plaque and oral bacteria counts. It demonstrates rapid bactericidal action and prolonged bacteriostatic action due to adsorption onto the pellicle-coated enamel surface. ** If it is not deactivated, chlorhexidine lasts longer in the mouth than other mouthwashes, which is partly why it is to be preferred over other treatments for gingivitis. Chlorhexidine is a component of many dental products and materials. Inactivation occurs when chlorohexidine is combined with fluoride products or blood proteins. Although data are limited, to maximize effectiveness, it is best to establish more than a 30-minute interval between brushing and using the mouthwash, "cautiously close to 2 hours after brushing" There are oral pathologic conditions where the maintenance of oral hygiene with the twice-daily use with 0.12% chlorhexidine gluconate solution (in which a salt of chlorhexidine and gluconic acid has been dissolved) is recommended for healing and regeneration of the oral tissues. These conditions include gingivitis, periodontitis, dental traumas (such as subluxation), oral cysts, and following wisdom tooth extraction. The clinical efficacy of the application of chlorhexidine as a component of oral rinses is well documented by many clinical studies summarized by review articles. Continued use of products containing chlorhexidine for long periods can cause stains on teeth, tongue, and gingiva, also on silicate and resin restorations; prolonged use can also produce bitter and salty taste sensations. This latter symptom can be reversed by discontinuing use of chlorhexidine. The brownish discoloration of teeth and tongue is due to the disintegration of bacterial membranes. According to the prescribing information, chlorhexidine gluconate has not been shown to reduce subgingival calculus and in some studies actually increased deposits. When combined with xylitol, a synergistic effect has been observed to enhance efficacy. The role of chlorhexidine in combination therapy with other agents to control dental disease remains a fruitful area for further investigation.

Betadine

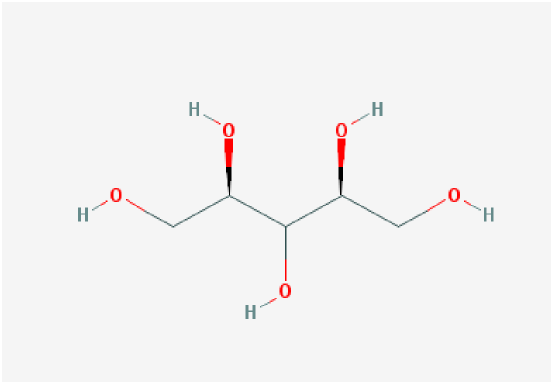
Povidone-iodine (PVP-I), also known as iodopovidone, is an antiseptic used for skin disinfection before and after surgery. It can be used both to disinfect the skin of the patient and the hands of the healthcare providers. It also may be used for minor wounds.

It is not recommended in people who are pregnant and less than 32 weeks in gestation or are taking lithium. Frequent use is not recommended in people with thyroid problems. Povidone-iodine is a chemical complex of povidone and the element iodine. It contains from 9% to 12% available iodine and works by releasing iodine which results in the death of a range of microorganisms.

Some authors have recently suggested the application of povidone-iodine prior to fluoride varnish to control cariogenic microorganisms *(Milgrom, Tut, & Mancl, 2011*). Further investigation of this proposal is indicated.

Xylitol

Early studies from Finland in the 1970s found that compared to chewing sucrose-flavored gum, xylitol flavored gum resulted in fewer cavities or missing teeth. Cavity-causing bacteria



prefer six-carbon sugars or disaccharides, while xylitol is a non-fermentable pentose and cannot be used as an energy source while continuing to be absorbed taken up into the cell (due to similar shape) and leaving no room for the six-carbon sugars, interfering with bacterial growth and reproduction. The harmful micro-organisms are starved in the presence of xylitol, allowing the mouth to remineralize damaged teeth with less ongoing acid production. At least six grams of xylitol per day is thought to be needed for dental efficacy.

The perception of sweetness obtained from consuming xylitol causes the secretion of saliva which acts as a buffer against the acidic environment created by the microorganisms in dental plaque. Increase in salivation can raise the falling pH to a neutral range within few minutes of xylitol consumption.

In the 33-month Xylitol for Adult Caries Trial, participants were given lozenges of either five grams of xylitol or a sucralose-sweetened placebo. While this study initially found no statistically significant reduction in 33-month caries increment among adults at an elevated risk of developing caries, a further examination of data from this study revealed a significant reduction in the incidence of root caries in the group that received xylitol (*Ritter et al., 2013*).
Xylitol is categorized by the U.S. Food and Drug Administration as a food additive. Like other sugar alcohol-sweetened products, xylitol-sweetened products are allowed to be labeled with the claim that they do not promote dental cavities.

Sodium Hypochlorite

(This subsection is submitted by Dr. Kim Kutsch)

Studies performed on the “killing” of biofilms have revealed some interesting results. While a “free floating” bacterial cell (planktonic) can be incredibly easy to kill, bacteria that have formed a biofilm can be incredibly resistant to antibacterials and antibiotics (*Wolcott, Fletcher, Schultz, & Phillips, 2010*). Further observations, using microscopy, have revealed that the longer a bacterial biofilm population resides, the more ordered the biofilm structure becomes. As the cells in the biofilm become more ordered and tightly packed, the biofilm becomes harder and harder to penetrate. Studies have shown that once bacteria cooperate and form a biofilm, they further enhance their survival (*Cho et al., 2007*). It is suggested that there are three ways to remove or kill an established biofilm: complete mechanical debridement (which is impossible in the mouth), heat in excess of 400°F (which would destroy tooth structure), and a very strong oxidizing agent capable of penetrating a biofilm (*“Center for Biofilm Engineering - Center for Biofilm Engineering | Montana State University,” 2019*). For this reason, a broad-spectrum oxidizing antibacterial agent capable of penetrating a biofilm, such as sodium hypochlorite, maybe considered as part of a treatment strategy.

The Medical Management of Caries has historically included fluoride in different delivery agents and antimicrobial or antibacterial therapy. Numerous antibacterial agents have been used, including ethyl alcohol, essential oils, chlorhexidine, and povidone iodine. While ethyl alcohol can be an effective antibacterial agent, it has obvious issues and has also been linked to oral cancer (*Winn et al., 1997*) (*Werner & Seymour, 2009*) (*McCullough & Farah, 2008*). Essential oils have been used for years as an antibacterial agent, but most commonly for the treatment of gum disease. Because dental caries is a biofilm disease, and biofilm diseases may be treated with a strong oxidizing agent, sodium hypochlorite has been introduced as an antibacterial agent. Sodium hypochlorite 0.2% oral rinse is bactericidal to all bacteria on contact. Limitations are alteration of taste and not recommended for use on patients under six years of age. The FDA considers oral rinse solutions with less than 0.3% concentration of sodium hypochlorite safe for daily use. Sodium hypochlorite 0.2% oral rinse is also being prescribed for oral conditions other than caries. Clinicians have reported positive results when prescribed for periodontal disease (biofilm imbalance below the gumline) as well as mouth ulcers (canker sores). Many patients who are undergoing dental treatment such as root canals, orthodontics, crown work, or bridgework, and implants may be provided 0.2% sodium hypochlorite oral rinse for home use to reduce the bioburden during restorative or cosmetic treatment plans.

References

Center for Biofilm Engineering - Center for Biofilm Engineering | Montana State University. (2019). from Montana.edu website: http://www.biofilm.montana.edu/

Cho, H., Jönsson, H., Campbell, K., Melke, P., Williams, J. W., Jedynak, B., … Levchenko, A. (2007). Self-Organization in High-Density Bacterial Colonies: Efficient Crowd Control. PLoS Biology, 5(11), e302. https://doi.org/10.1371/journal.pbio.0050302

P Debré. (1998). Louis Pasteur / Louis Pasteur. Baltimore: Johns Hopkins University Press.

Duffin, S. (2019). The Medical Management of Caries: A Paradigm Shift? from Thelundreport.org website: https://www.thelundreport.org/search?terms=duffin

Duffin, S. (2012). Back to the future: the medical management of caries introduction. Journal of California Dental Association, 40(11), 852–858.

Featherstone, J. (2006). Caries Prevention and Reversal Based on the Caries Balance. Pediatric Dentistry, 28(2), 128–132.

Galván, M., Gonzalez, S., Cohen, C. L., Alonaizan, F. A., Chen, C. T.-L., Rich, S. K., & Slots, J. (2013). Periodontal effects of 0.25% sodium hypochlorite twice-weekly oral rinse. A pilot study. Journal of Periodontal Research, 49(6), 696–702. https://doi.org/10.1111/jre.12151

Gotjamanos, T. (1997). Safety issues related to the use of silver fluoride in paediatric dentistry. Australian Dental Journal, 42(3), 166–168. https://doi.org/10.1111/j.1834-7819.1997.tb00115.x

McCullough, M., & Farah, C. (2008). The role of alcohol in oral carcinogenesis with particular reference to alcohol-containing mouthwashes. Australian Dental Journal, 53(4), 302–305. https://doi.org/10.1111/j.1834-7819.2008.00070.x

Mei, M. L., Lo, E. C. M., & Chu, C. H. (2018). Arresting Dentine Caries with Silver Diamine Fluoride: What's Behind It? Journal of Dental Research, 97(7), 751–758. https://doi.org/10.1177/0022034518774783

Mickenautsch, S., & Yengopal, V. (2012). Anticariogenic effect of xylitol versus fluoride - a quantitative systematic review of clinical trials. International Dental Journal, 62(1), 6–20. https://doi.org/10.1111/j.1875-595x.2011.00086.

Milgrom, P., Tut, O., & Mancl, L. (2011). Topical Iodine and Fluoride Varnish Effectiveness in the Primary Dentition: A Quasi-experimental Study. Journal of Dentistry for Children, 78(3), 143–147.

Ritter, A. V., Bader, J. D., Leo, M. C., Preisser, J. S., Shugars, D. A., Vollmer, W. M., … Holland, J. C. (2013). Tooth-surface-specific Effects of Xylitol. Journal of Dental Research, 92(6), 512–517. https://doi.org/10.1177/0022034513487211

Russell, A. D., & Hugo, W. B. (1994). 7 Antimicrobial Activity and Action of Silver. Progress in Medicinal Chemistry, 31, 351–370. https://doi.org/10.1016/s0079-6468(08)70024-9

Werner, C. . W. de A., & Seymour, R. A. (2009). Are alcohol containing mouthwashes safe? British Dental Journal, 207(10), E19–E19. https://doi.org/10.1038/sj.bdj.2009.1014

Winn, D., Blot, W., McLaughlin, J., Austin, D., Greenberg, R., Preston-Martin, S., … Fraumeni Jr., J. (1997). Mouthwash Use and Oral Conditions in the Risk of Oral and Pharyngeal Cancer. Cancer Research, 51(11).

Wolcott, R. D., Fletcher, J., Schultz, G., & Phillips, P. L. (2010). Biofilms Made Easy. Wounds International. Retrieved from https://www.woundsinternational.com/resources/details/biofilms-made-easy-wint

Biological Mechanisms of Silver Diamine Fluoride

(Dr. Jeremy Horst, DDS, PhD)

Abstract

Silver Diamine Fluoride is the first pharmacological treatment governmentally approved for use against dental caries (e.g. Japan in 1970, Canada in 2017). The effectiveness of treating individual cavitated carious lesions is estimated by meta-analysis to be 81% (*Gao et al., 2016*), which is similar to composite fillings placed in similar high caries rate public health situations (*Bucher et al., 2015*). As a preventive, it outperforms all other modalities besides sealants, approximately 61% fewer new lesions throughout the mouth (*Horst & Heima, 2019*). However, it is not a cure nor vaccine. It could be better. Ours and other research groups, particularly those in Hong Kong University, are investigating the mechanisms of Silver Diamine Fluoride. A deeper understanding of how Silver Diamine Fluoride works is sought to lay the foundation for characterizing its limitations and improving its capabilities. As there are with antibiotic resistance, are there clinically assessable or laboratory testable features that indicate when Silver Diamine Fluoride will not work? Similarly, can these features inform ways to make Silver Diamine Fluoride more effective? This section elaborates current progress toward answering these questions through a review of the technologies applied. The conclusion is a more complete understanding of the biological mechanisms of Silver Diamine Fluoride treatment response and continued caries activity refractory to Silver Diamine Fluoride treatment.

Introduction

Our scientific understanding of the level of Silver Diamine Fluorides clinical effectiveness in preventing and treating dental caries far surpasses our mechanistic understanding of how it actually works. If Silver Diamine Fluoride were nearly 100% effective in controlling caries, or negligibly effective, it might not be important to elaborate its mechanisms. However, with 81% of cavitated dentin caries lesions arresting after Silver Diamine Fluoride treatment and 61% of new caries lesions prevented (*Horst and Heima, 2019*), Silver Diamine Fluoride is a powerful intervention. Its effectiveness surpasses all other pharmacological agents in each category. But it is incomplete. Mechanistic research must be done to inform the development of more effective therapeutics for the future and to guide appropriate clinical use now. It may indeed be most important to understand how and when Silver Diamine Fluoride is not effective (failure mode).

Generally, Silver Diamine Fluoride inhibits bacterial growth, hardens tooth structures weakened from caries, and improves the resilience of the tooth to demineralization

(*Rosenblatt et al., 2009*) (*Horst et al., 2016*) (*Zhao et al., 2018*). But, there are unresolved subtleties with profound clinical importance. One of the greatest challenges of developing topical therapies for dental caries is substantivity: how long does the material stay in place in an activated / activatable form? This is where Silver Diamine Fluoride seems to dramatically differ from all other materials that have been developed to treat caries: the silver and the fluoride stay in the weakened parts of the tooth, strengthening the tooth until insult by cariogenic bacteria, whereupon the silver ions are released to slow and kill the bugs.

In this essay we summarize the current state of knowledge about how Silver Diamine Fluoride works to treat and to prevent dental caries in enamel and dentin. Multiple technologies inform this understanding. These technologies range from traditional to novel and from simplistic to complex. We have structured this discussion by technology.

Historic Cariology

As explained in a chapter by Dr. Duffin, bacterial culture has been used since the 1880s to investigate the identity, abundance, and behaviors in isolation of "tooth worms," which were renamed "bacteria" when cultivated from dental plaque and caries lesions. The results of enormous volumes of work from across the globe over the last century and a half is that: caries is caused by sugars being fermented by dental plaque bacteria into acids which then dissolve the tooth. Also, enzymes from the bacteria and the tooth itself degrade the proteinaceous part of the dentin. Caries is strongly associated with various species within the bacterial genera of streptococcus and lactobacillus. Certain of these bacteria have been shown to induce caries in laboratory animals previously devoid of bacteria (gnotobiotic). Modern molecular genetic techniques have further delineated patterns in these and previously unknown bacterial groups.

Several bacteria have been shown to satisfy Koch's postulates of causality for dental caries: being present in diseased tissues (carious lesions); being present in the patient prior to the onset of disease; inducing the disease in animals; and, finally being retrieved from diseased tissues in those animals. However, these particular bacteria cannot be found in a significant proportion of carious lesions. Furthermore, patients can be shown to be carrying these bacteria for a long time without showing any signs of disease. Thus, many microbes can cause or influence dental caries, and ultimately the cause seems to be the combination of sugars, bacteria, and time. While some research investigates effects on tooth structure, most biological research on Silver Diamine Fluoride focuses on its effects on dental plaque bacteria.

Disc Diffusion Assay

A few bacteria associated with or shown to cause cavities have been tested for sensitivity to Silver Diamine Fluoride in various conditions. The following steps are generally taken to evaluate the sensitivity of a bug to a drug. First, bacteria are isolated from plaque or cavities by spreading an inoculum onto petri dishes with agar ingredients that only a subset of species can grow upon (selective culture). A similar process is then used in the **disc diffusion assay** wherein the bacteria are spread across the petri dish, a small circle of absorbent paper is put over a portion of the bacteria, the drug is deposited onto the paper, and after allowing a couple days for growth the effectiveness of the particular drug concentration is determined by the distance of the closest bacterial colony growth to the paper. It can be used to quickly compare different products or concentrations thereof.

This assay depends on the diffusion of the drug laterally across the dish. As silver is susceptible to precipitation in light and with reaction to other chemicals, there are limitations to this model. One particular strength of this model compared to the more commonly used liquid broth, is the increased relevance of biofilm to dental caries.

Growth Assay

Growth in liquid broth media is easier to quantify and to quickly set up many reactions to test different conditions, and is therefore generally more used in biology. This assay is so ubiquitous it is simply called a **growth assay**. Measurements of bacterial growth in these conditions is determined by the optical density, or turbidity of the culture liquid: more bacteria will block more light shining through. While bacterial culture as such is not particularly sophisticated, many permutations can be performed. Here, precipitated silver or aqueous silver in ionic state interact with bacteria in the liquid. The great limitation of this model for caries is that bacteria do not cause caries in this planktonic liquid-based state. This model has been used to define the minimum inhibitory concentration or MIC for preventing growth of *Streptococcus mutans,* the bacteria most commonly associated with caries) to 26 µg Silver Diamine Fluoride per milliliter of liquid (0.0026%, 162 µM, range 19-33 µg/mL), above which it does not grow (*Suzuki et al. 1976*) (*Targino et al., 2014*) (*Zhao et al., 2018*). Bacterial kill is confirmed either by sub-culturing onto agar plates without any drug, or by molecular markers that assess for cell wall integrity. Using the sub-culturing technique, the minimum bactericidal concentration (MBC) for the same bacterium has been shown to be a bit higher, 50 µg/mL (*Targino et al., 2014*).

We have used this model to show that Silver accounts for the majority of the antimicrobial effectiveness, but that Fluoride also contributes at a rate of ~1:4 (*unpublished data*). It is important to note that the MIC of Silver Fluoride is 160,000 times higher than the 1 nM drug efficacy sought by modern pharmaceutical developers for other diseases - and yet it works! It may indeed be the promiscuity of action by the silver ion that makes it work so well - a study that examined the MBC of Silver Nitrate against 18 diverse oral bacterial species showed that all were killed at 1 mM (*Youravong et al., 2011*). Indeed, all microbes that can cause infections in severe burns are killed with similar levels of Silver (*Klasen, 2000, 10716355*).

Agar Drug Sensitivity Assay

Another culture technique incorporates different concentrations of Silver Diamine Fluoride into the petri dish agar, such that each petri dish is a different condition. This is an **agar drug sensitivity assay**. Using modern laboratory robotics, many bacterial samples can be placed on the same dish, resulting in a multiplexed assay. We have used this approach to compare the sensitivity of *Strep mutans* isolates to Silver Diamine Fluoride, Silver, and Fluoride. We isolated *Strep mutans* from each of 80 samples from the *Stopping Cavities placebo-controlled trial*, and compared the ability of the microbes cultured from Silver Diamine Fluoride arrested lesions versus those that remained active to grow on dishes made with increasing concentrations of these ions. We hypothesized that isolates from lesions that stayed active would grow at higher levels of Silver Diamine Fluoride demonstrating traditional drug resistance. However, we found that all isolates stopped growing at 200 µg/mL Silver Diamine Fluoride. The only pattern found in analyzing these isolates was that those from lesions that stayed active simply grew faster and more densely (*unpublished data*). It should be noted that this *Strep mutans* biofilm MIC is 8 times higher than that found in the liquid media *growth assays*. **This underscores the differences in important physiologic properties such as drug susceptibility between planktonic and biofilm states**. Thus, current science supports the hypothesis that persistent lesion growth after Silver Diamine Fluoride treatment may be caused by forms cariogenic bacteria that grow faster than others.

Flow Cell

The above models can be combined into a flow cell, wherein bacteria are grown in the biofilm state, as on a petri dish, with liquid media continually running over the bacteria, providing access to a change in the nutrients or drug throughout growth – and thereby the ability to more closely simulate the natural environment. This model is more representative of caries and has been under-utilized in this particular aspect of research. It has essentially been used to show that the clinically used concentration of Silver Diamine Fluoride (38%) kills multi-species biofilms (*Mei et al., 2013*).

Dentin Disc Model

Some shortcomings of these *in vitro*, or *in media*, models are overcome by *ex vivo* models. Slices of freshly cut dentin from human or cow teeth are inoculated with bacteria, fed by liquid media, and monitored for vitality of the bacteria and degradation of the tooth (e.g. demineralization). This **dentin disc model** has the advantage of a more realistic representation of how the drug is taken up by the tooth, termed substantivity. This model has been extremely useful to assess the effect of short application of drug onto the tooth (e.g. 1 minute) on longer-term effects on bacterial growth (e.g. 1 week). Using this model, it was discovered that the effect of Silver Diamine Fluoride on preventing bacterial growth is dramatically increased when the dentin is demineralized prior to application (*Knight et al., 2007*).

These experiments opened the realization that Silver Diamine Fluoride has two courses of action: bacterial kill in the minutes following application and prevention of bacterial ingrowth during the months to years thereafter. This was most beautifully characterized by growing *Strep mutans* with sugar on and within dentin slices for one week, treating with Silver Diamine Fluoride, lightly rinsing, and then re-submerging in *Strep mutans* and sugar for another week. A pair of fluorescent microscopy markers were used to show living versus dead bacteria. These experiments showed clearly that in ideal conditions Silver Diamine Fluoride can penetrate far into the tooth to kill invading bacteria yet, eventually the bacteria can overwhelm the remnant Silver Diamine Fluoride and more slowly reinvade from the outside of the tooth (*Hamama et al., 2015*).

Enzymatic Inhibition

Deeper mechanistic details that could have important clinical implications can be deciphered by evaluating only the effect on the enzymatic function of an individual protein. The **enzymatic inhibition** is tested by exposing the isolated enzyme, or much more commonly, the enzyme artificially expressed by a genetically engineered bacterium, without any microbial or host cells, to a range of drug concentrations and assessing the output of the enzyme. To our knowledge, every tested enzyme is inhibited by Silver Diamine Fluoride and even Silver Nitrate (*Klasen, 2000*). Not only do the assessed enzymes include those critical to sugar fermentation and plaque production by cariogenic bacteria (*Suzuki et al., 1976*), but also proteins that are constitutively present in dentin and degrade the collagenous dentin matrix when released by demineralization (*Mei et al., 2012*)

(*Mei et al., 2014*). It is important that the particular enzymes that have been carefully assessed are taken as examples to inform the bigger picture: the Silver ion is a wrecking ball that will effectively coagulate and thereby passivate any protein enzyme. With this information, the next step must be to focus on escape mechanisms that bacteria use to survive higher levels of Silver, which have only been initially explored. (*Finley et al., 2015*).

Strep Mutans Counts

The next most relevant biological assay for the response to and mechanisms of Silver Diamine Fluoride, is microbiological sampling from actual patients before and after treatment. Traditionally, dental antimicrobials are tested by counting the colonies of *Strep mutans* that grow on selective media (**Strep mutans counts**). This assay can be very useful due to its direct connection to the clinical situation, although limitations stem from this specific microbe not being found in many patients with caries, and a less perfect association between the abundance of the microbe and disease activity. Still, consistent findings would help to build a mechanism. Surprisingly, to our knowledge no one has yet completed such a study. Instead, more sophisticated sampling assays have been done.

Culture to 16S-Sanger

Dr. Rella Christensen and her team at Technologies in Restoratives and Caries (TRAC) have performed extensive evaluation of a handful of Silver Diamine Fluoride treated cavities using a **culture to 16S-Sanger** characterization process. They developed their scheme while evaluating the remnant viable bacteria under fillings and other treatments by creating a relatively sterile field around the tooth, using sophisticated isolation barriers they have benchmarked through decades of work, and using a new sterile 1/8 round bur each to remove 1 mg increments of tooth structure, then porting these increments directly to bacterial culture, first liquid media then agar, from which individual bacterial colonies are picked by morphology, and identified by amplifying a portion of the gene encoding the 16S ribosomal RNA by PCR, performing Sanger DNA sequencing thereof, and comparing the resulting 1,000 or so nucleotide long sequences to a rigorously developed database of sequences. This particular gene is exploited for this purpose because literally all bacteria spanning a stunningly large and diverse range of the tree of life, have this gene. Further, there are universally conserved regions of the gene which are separated by highly divergent regions of the gene. PCR probes target the regions that are the same (conserved) in all bacteria, and the divergent areas between are read out to identify each bacterial species or genius. Dr. Christensen and colleagues have used this methodology to show that many viable bacteria remain under all sorts of fillings, and in carious lesions treated with Silver Diamine Fluoride. They have proven that some bacteria either remain in or re-invade the lesion following Silver Diamine Fluoride treatment (*Dr. Rella Christensen, personal communication*).

This finding is astounding. Bacteria remain under Silver Diamine Fluoride-treated lesions. Are they active? What are they doing? Did they simply reawaken upon introduction to bacterial cell culture? From the sequential images, it seems that in the teeth studied by Dr. Christensen the Silver Diamine Fluoride did not penetrate down far enough to kill all the bacteria. Still, the finding is difficult to interpret in the context of the fact that most of these lesions do not grow over many years. While the individual lesions studied were not followed clinically and radiographically for any significant time prior to being opened, their findings are consistent to all lesions they have studied - at least some of the studied lesions should have been arrested. Thus, current science suggests that <u>Silver Diamine Fluoride-induced caries arrest does not disinfect or necessarily prevent reinfection of infected carious lesions</u>. We must be careful not to draw conclusions about the status of a lesion from the ability to cultivate bacteria from it. All bacteria have quiescent states. Without access to sugars, cariogenic bacteria cannot grow or further the caries process. The clinical trial literature on sealing in active carious lesions in permanent teeth with resin (*Mertz-Fairhurst et al., 1998*) and that on sealing in advanced lesions in primary teeth with glass ionomer cement and stainless-steel crowns using the Hall technique (*Innes et al., 2017*) shows with the highest levels of evidence that removing bacteria from the carious lesion is entirely irrelevant to successful treatment. Still, it has been assumed that the bacteria die when cut off from nutrient sources. Dr. Mertz-Fairhurst went to great extent to evaluate successfully sealed lesions, sampled 4-17 months after treatment, and consistently found no viable *Strep mutans* (*Mertz-Fairhurst et al., 1979*). Dr. Christensen's work completely undercuts this finding; the techniques certainly appear to be more sensitive to microbial viability.

Microbiome

A similar approach of bacterial identification is now broadly used in biomedical research to profile the relative abundance of all bacteria in a sample. The same afore mentioned 16S ribosomal RNA gene is amplified by PCR from an entire complex sample and input into next generation sequencing (NGS) to read hundreds of thousands of individual copies of the gene per sample. This is called "16S-NGS," or more commonly: **<u>microbiome</u>** assessment. In essence, this sampling of 16S gene sequences estimates the distribution of bacteria in the original sample, by counting instances of sequences matching each bacterium. The limitations of this method are that a DNA sequence matching a bacterium does not reflect vitality nor activity and microbes less abundant in proportion to the others than the number of sequences taken for that sample will not be observed. For example if an important bacterium makes up one millionth of the sample, and only a hundred thousand sequences are read, the microbe will probably be missed. However, this depth of characterization is far greater than the *culture to Sanger 16S* characterization, and indeed novel low-abundance but highly correlative bacteria have been identified and correlated to caries with this technique. Another limitation is that the comparatively short sequence reads, ~200 nucleotides long, are not always unique enough to identify species and sometimes not even to identify genus. Thus for some taxonomic groups only genus or family can be evaluated. As well, this technique only gives relative abundance not real counts due to normalization steps in laboratory processing taken to ensure each sample gets enough reads and subsampling of the original sample.

Nonetheless, we have used the *microbiome* technique to evaluate the change in the profile of bacteria over time after Silver Diamine Fluoride treatment. In one study we performed in depth evaluation of two patients: two cavities, one healthy tooth, and the saliva, each at baseline, then 1, 4, 7, 14, and 30 days later. In another study we compared the salivary microbiomes of children from the same Ghanaian village a year after Silver ion treatment by Dr. Duffin. We studied 10 children in each of the following categories: all carious lesions arrested, lesions not arrested, who have never had caries, and who had none the year prior but now have new untreated caries. In these two studies, we were surprised that <u>no consistent</u>

significant changes or differences were observed in the relative abundance of bacteria in the saliva or plaque of patients whose carious lesions successfully stopped following Silver ion treatment (*unpublished data*). Certainly there were visibly less bacteria present, but the microbiomes (the distribution of the bacteria by composition of species and genera) did not change or differ. We saw this as a particularly important finding because antibiotics when used for other types of infections can dangerously shift the composition of gut bacteria, driving side effects such as diarrhea, which can be persistent and incapacitating. So the lack of change to the composition of bacteria in the saliva or on the cavities of patients successfully treated with silver ion is surprising – and reassuring.

When comparing the salivary microbiome of patients whose lesions were all arrested to those whose lesions persisted in activity, we observed much higher levels of *Strep mutans* and *Propionibacterium acnes* (*unpublished data*). While we initially thought *P. acnes* must have been a contaminant, both species are consistent with the bacteria that have been consistently cultivated from deep underneath Silver ion treated lesions by the TRAC group.

mNGS

Finally, the most comprehensive, representative, and unbiased measure of microbes in a complex sample is achieved by applying **metagenomic next generation sequencing** (mNGS). This process is similar to 16S-NGS, but instead of amplifying one part of one gene, the PCR probes are astronomically diverse, designed to amplify any genes from any branch of life. Because this technique is robust to any RNA or DNA based life form, we use this technique to identify viruses, protozoa, fungi, and bacteria in infectious disease. We also use the same data for a particular sample to assess and compare expression of all genes in the diseased host organism (human, bird, snake, cat, etc.). This technique is substantially more expensive than the alternatives because the sequencing depth must be at least 200 times deeper for each sample (at least 20M reads) to get a similar representation of the diversity of species in a sample. As well, analysis is far more complex, time consuming, and being actively developed, largely by the UCSF DeRisi lab and the Chan-Zuckerberg BioHub, where we performed this work. There are numerous further advantages to this method due to how the greater depth of information yields higher specificity and sensitivity for identifying microbes and their genes and genotypes.

We have now applied mNGS to two sets of samples from the *Stopping Cavities trial* (*Milgrom & Horst, 2018*). In the first set, we compared the changes (after versus before) in mNGS microbial profiles for pairs of lesions from each of 3 patients whose lesions were arrested with Silver Diamine Fluoride to those from 3 patients treated by a placebo (24 samples total). We were shocked to see a lack of consistent changes similar to that described with microbiome analyses above. When we used the same data to evaluate anti-microbial and anti-metal resistance genes, no differences were found, again supporting safety [*Milgrom and Horst et al., 2018*].

We also performed mNGS analysis to evaluate changes (after versus before) in 26 teeth treated with Silver Diamine Fluoride, 10 which successfully stopped and 16 which remained active (52 samples). In this more diverse sample, we saw an increase in *Lactobacillus reuteri* in the successfully arrested lesions. Perhaps not coincidentally, this bacterium is in consideration for a probiotic to protect against dental caries. Comparing between lesions that arrested versus lesions that remained active, before treatment, *Parascardovia denticolens* was significantly higher in lesions that went on to remained active. Comparing samples after treatment, *Porphyromonas circumdentaria* was higher in lesions that had grown. When comparing samples taken from lesions that grew after treatment to the same lesions before treatment, *Streptococcus parasanguinis* and *Rothia mucilaginosa* were more abundant after persistent growth than before Silver Diamine Fluoride treatment (*unpublished data*).

Summary

While the clinical effectiveness of Silver Diamine Fluoride has been sufficiently assessed, there are still many mysteries in the biological mechanisms of treatment success and failure. Solving these mysteries would be extremely valuable to guide clinical use. Yet what is now known can help. Silver Diamine Fluoride kills cariogenic bacteria at 19,000th the concentration of which it comes out of the bottle; a little dilution in the clinical setting won't hurt, and a little material will go a long way. As seen with the stain, more Silver Diamine Fluoride is absorbed in more advanced lesions, and this results in more resistance to future bacterial growth. Effort should be made to get more Silver Diamine Fluoride into bigger lesions. The long-term effect also seems to depend on how much Silver Diamine Fluoride remains in the lesion. Re-application is paramount and should follow the level of caries activity.

Some surprising patterns are seen. Maintenance of viable bacteria under SDF-treated lesions is disconcerting. A lack of substantial consistent shifts in the microbiome following SDF-induced caries arrest opens many questions about how this presumed antimicrobial actually works. Silver Diamine Fluoride may work by making the tooth substantially more resistant to microbial ingrowth. It does not disinfect the lesion. Initial results show that faster growing *Strep mutans* reside in lesions that persistently grow after Silver Diamine Fluoride treatment. Thus, initially treatment-resistant lesions may respond to more rapidly sequential SDF applications and combinations with other effective anti-caries antimicrobials such as Tin or Iodine. Initial leads have been found to characterize the identity and mechanisms of bacteria that could confer persistent activity after Silver Fluoride treatment.

More research on clinical samples connecting changes in clinical outcomes over time is needed to elucidate the biological mechanisms of success and failure of Silver Diamine Fluoride for treating dental carious lesions.

References

Bücher, K., Metz, I., Pitchika, V., Hickel, R., & Kühnisch, J. (2014). Survival characteristics of composite restorations in primary teeth. Clinical Oral Investigations, 19(7), 1653–1662. https://doi.org/10.1007/s00784-014-1389-9

Finley, P. J., Norton, R., Austin, C., Mitchell, A., Zank, S., & Durham, P. (2015). Unprecedented Silver Resistance in Clinically Isolated Enterobacteriaceae: Major Implications for Burn and Wound Management. Antimicrobial Agents and Chemotherapy, 59(8), 4734–4741. https://doi.org/10.1128/aac.00026-15

Gao, S. S., Zhao, I. S., Hiraishi, N., Duangthip, D., Mei, M. L., Lo, E. C. M., & Chu, C. H. (2016b). Clinical Trials of Silver Diamine Fluoride in Arresting Caries among Children. JDR Clinical & Translational Research, 1(3), 201–210. https://doi.org/10.1177/2380084416661474

Horst, J. A., Ellenikiotis, H., & Milgrom, P. L. (2016). UCSF Protocol for Caries Arrest Using Silver Diamine Fluoride: Rationale, Indications and Consent. Journal of the California Dental Association, 44(1), 16–28. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4778976/

Horst, J., & Heima, M. (2019). Prevention of Dental Caries by Silver Diamine Fluoride. Compendium of Continuing Education in Dentistry, 40(3), 158–163.

Innes, N. P., Evans, D. J., Bonifacio, C. C., Geneser, M., Hesse, D., Heimer, H., … Santamaria, R. M. (2017). The Hall Technique 10 years on: Questions and answers. British Dental Journal, 222(6), 478–483. https://doi.org/10.1038/sj.bdj.2017.273

Klasen, H. . (2000). A historical review of the use of silver in the treatment of burns. II. Renewed interest for silver. Burns, 26(2), 131–138. https://doi.org/10.1016/s0305-4179(99)00116-3

Knight, G., McIntyre, J., Craig, G., Zilm, P., & Gully, N. (2007). Differences between normal and demineralized dentine pretreated with silver fluoride and potassium iodide after an in vitro challenge by Streptococcus mutans. Australian Dental Journal, 52(1), 16–21. https://doi.org/10.1111/j.1834-7819.2007.tb00460.x

Mei, M., Li, Q., Chu, C.-H., Lo, E. C.-M., & Samaranayake, L. (2013). Antibacterial effects of silver diamine fluoride on multi-species cariogenic biofilm on caries. Annals of Clinical Microbiology and Antimicrobials, 12(1), 4. https://doi.org/10.1186/1476-0711-12-4

Mei, May L., Ito, L., Cao, Y., Li, Q. L., Chu, C. H., & Lo, E. C. M. (2014). The inhibitory effects of silver diamine fluorides on cysteine cathepsins. Journal of Dentistry, 42(3), 329–335. https://doi.org/10.1016/j.jdent.2013.11.018

Mei, May L., Li, Q. L., Chu, C. H., Yiu, C. K. Y., & Lo, E. C. M. (2012). The inhibitory effects of silver diamine fluoride at different concentrations on matrix metalloproteinases. Dental Materials, 28(8), 903–908. https://doi.org/10.1016/j.dental.2012.04.011

Mertz-Fairhurst, E. J., Curtis, J. W., Ergle, J. W., Rueggeberg, F. A., & ADAIR, S. M. (1998b). Ultraconservative and cariostatic sealed restorations: results at year 10. The Journal of the American Dental Association, 129(1), 55–66. https://doi.org/10.14219/jada.archive.1998.0022

Mertz-Fairhurst, E. J., Schuster, G. S., Williams, J. E., & Fairhurst, C. W. (1979). Clinical progress of sealed and unsealed caries. Part I: Depth changes and bacterial counts. The Journal of Prosthetic Dentistry, 42(5), 521–526. https://doi.org/10.1016/0022-3913(79)90245-2

Milgrom, P., Horst, J. A., Ludwig, S., Rothen, M., Chaffee, B. W., Lyalina, S., … Mancl, L. (2018). Topical silver diamine fluoride for dental caries arrest in preschool children: A randomized controlled trial and microbiological analysis of caries associated microbes and resistance gene expression. Journal of Dentistry, 68, 72–78. https://doi.org/10.1016/j.jdent.2017.08.015

Rosenblatt, A., Stamford, T. C. M., & Niederman, R. (2009). Silver Diamine Fluoride: A Caries "Silver-Fluoride Bullet." Journal of Dental Research, 88(2), 116–125. https://doi.org/10.1177/0022034508329406

Suzuki, T., Tsutsumi, N., Sobue, S., & Suginaka, H. (1976). Effect of diammine silver fluoride on plaque formation by Streptococcus mutans. Japanese Journal of Oral Biology, 18(3), 268–278. https://doi.org/10.2330/joralbiosci1965.18.268

Targino, A. G. R., Flores, M. A. P., dos Santos Junior, V. E., de Godoy Bené Bezerra, F., de Luna Freire, H., Galembeck, A., & Rosenblatt, A. (2014). An innovative approach to treating dental decay in children. A new anti-caries agent. Journal of Materials Science: Materials in Medicine, 25(8), 2041–2047. https://doi.org/10.1007/s10856-014-5221-5

Youravong, N., Carlen, A., Teanpaisan, R., & Dahlén, G. (2011). Metal-ion susceptibility of oral bacterial species. Letters in Applied Microbiology, 53(3), 324–328. https://doi.org/10.1111/j.1472-765x.2011.03110.x

Zhao, I. S., Gao, S. S., Hiraishi, N., Burrow, M. F., Duangthip, D., Mei, M. L., … Chu, C.-H. (2017). Mechanisms of silver diamine fluoride on arresting caries: a literature review. International Dental Journal, 68(2), 67–76. https://doi.org/10.1111/idj.12320

Probing the Human Oral Microbiome

(Dr. Steve Duffin, DDS and Marcus Duffin, MS, MBA)

One of the more powerful tools available today in the identification of particular bacterial species employs the examination of bacterial DNA sections that code for species specific RNA molecules. Historically, the task of bacterial species identification involved a tedious series of steps involving dilution and plate cultivation with specific nutrient media. Today, we can obtain huge quantities of DNA from small samples using high throughput DNA polymerization technologies. These samples can then be analyzed for species specific markers. There now exist simple kits for obtaining biologic samples which are then analyzed and a report sent back to the investigator. Saliva represents a simple way to obtain a snapshot of bacteria present in an individuals' mouth. Special thank you to Page Caufield, D.D.S., Ph. D. who pioneered the techniques necessary for tracking oral bacterial transmission between mother and infant (*Caufield, Cutter, & Dasanayake, 1993*).

Previous efforts using culture-based techniques may have missed important players in understanding the complex dynamic environment of the human oral microbiome. As we write this manuscript, the SMART Community of clinicians and scientific investigators are collecting samples for a global oral microbiota atlas of patients with and without caries, in various populations around the world. This is a work in progress and may reveal information that will prove useful in the prevention and management of dental diseases globally.

Disclosure, I (Steve Duffin) am the dental director of NoDK, LLC which is involved in this effort to build such a global microbiota atlas. I am also involved with the development of medical device technology, to facilitate the medical management of caries in alternative locations such as rural schools and long-term care facilities.

Hailey Taylor collecting saliva samples in Ghana.

Saliva collection in Copacabana Bolivia.

References

Caufield, P. W., Cutter, G. R., & Dasanayake, A. P. (1993). Initial Acquisition of Mutans Streptococci by Infants: Evidence for a Discrete Window of Infectivity. Journal of Dental Research, 72(1), 37–45. https://doi.org/10.1177/00220345930720010501

Saliva in Caries and in Oral Health

(Dr. Steve Duffin, DDS and Jacqueline Juhl, RDH, BS, MS)

To understand the human oral microbial environment, we must also understand the complexities of saliva. Saliva plays a major role in maintaining oral health. In addition to providing lubrication for facilitating food movement toward the stomach, saliva is the source of salivary amylase, the enzyme which initiates carbohydrate metabolism. Saliva also coats the teeth with proteins and a solution that is super-saturated with calcium and phosphate. The combination of the major and minor salivary glands produce between one and two liters of saliva daily, which serves as a medium to begin the dissolution of foods and other substances. This aqueous fluid is also the source of the protein compounds found in the enamel pellicle which coats the teeth. During transient periods when the pH of the oral cavity is lowered to a threshold level of pH 5 or less, by consumption of simple carbohydrates, including sugars and through bacterial metabolism, minerals leave the enamel tooth surface. Prolonged periods of bacterial-mediated mineral loss result in what is known as a cavity in the tooth surface. The calcium and phosphate present in saliva may assist to remineralize these areas in a process that has come to be known as the Caries Balance. The full appreciation for this process is beyond the scope of this text. That being said, anything that influences the quantity or quality of saliva will have profound effects on the caries balance and the risk for developing dental caries. Although there are other reasons for xerostomia, the condition of an insufficient quantity of saliva, one common cause of this condition is the increasing use of certain medications.

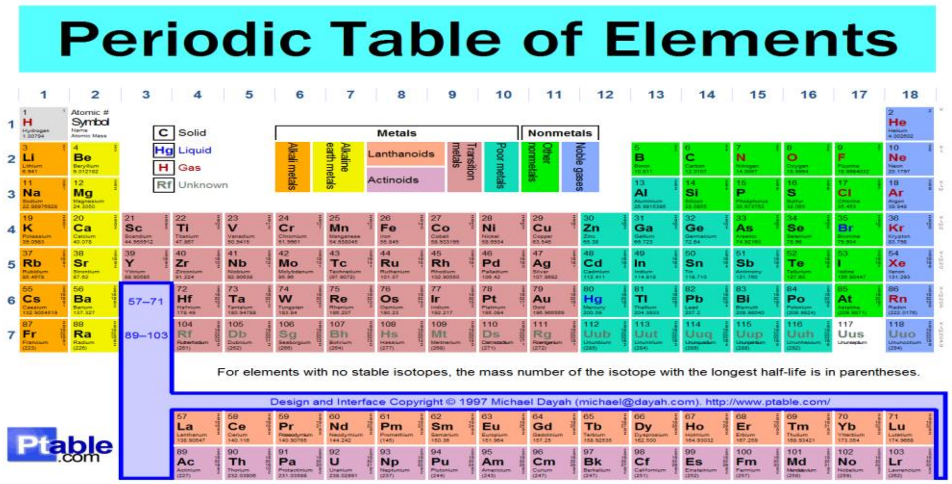
A simple salivary sample can be examined using genomic sequencing technology to identify the presence of bacteria down to the species level. This capability will allow both basic science research into the etiology of dental disease and the effects of therapeutic interventions on microbial inhabitants in the oral cavity. Complimenting these investigations is a new emerging field known as *salivary diagnostics*. Saliva is easily obtained and is derived from plasma and its composition may reflect certain medical conditions. Certainly, much remains to be learned about saliva and its role in health and disease.

References

Langille, M. G. I., Zaneveld, J., Caporaso, J. G., McDonald, D., Knights, D., Reyes, J. A., … Huttenhower, C. (2013). Predictive functional profiling of microbial communities using 16S rRNA marker gene sequences. Nature Biotechnology, 31(9), 814–821. https://doi.org/10.1038/nbt.2676

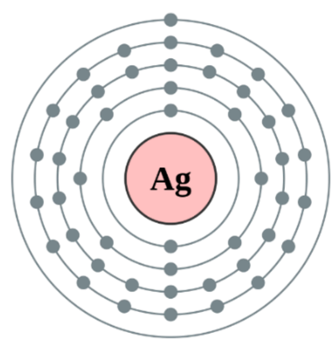
Science and Chemistry of Silver and Fluoride

(Dr. Steve Duffin, DDS and Marcus Duffin, MS, MBA)



A brief analysis of the principal active ingredients in silver fluoride products is worthy of mention. A comprehensive review of these topics should be sought elsewhere. The focus here is on the 38% silver diamine fluoride (SDF) product. Water is the primary component representing 62% by weight. Other elements by weight and respective percentages include: silver ions 25%, fluoride ions 5%, and ammonia 8%. Ammonia was presumably added to the original formulation to stabilize the silver and fluoride ions in solution. There does not appear to be much literature that describes how ammonia may act independently of silver and fluoride ions in producing the clinical effects of SDF. This represents yet another opportunity for further investigation. While there exists more information about the supposed mode of action of the silver and fluoride components of SDF, there yet remains knowledge gaps and opportunities for further investigation of these elements and of their activity individually and collectively with tooth structure and bacteria as well. The basic chemical properties of silver and fluoride will now be discussed following an exploration of the likely methods by which they act.

Silver



Silver is element #47 on the periodic table and has only one electron in its outer energy shell. This means that silver is also very reactive, and it tends to give up the outer electron in chemical reactions. When silver (Ag) loses its outer electron, it becomes a positively charged ion, (Ag+), and its movement in solution is influenced by electromagnetic fields. Bacterial cell walls composed of peptidoglycan are generally associated with having a net negative charge.

The differences in the respective ion charges will cause the Ag+ to be attracted toward the bacterial cell surface. Such Ag+ ions may gain access to the cytoplasmic space of the bacterial cell by diffusion through pores in the cell wall and membrane, or by active absorption processes. The presumed mode of action of silver ions in the inactivation of bacterial cells is via attachment to and alteration of the three-dimensional structure of critical cytoplasmic enzymes, DNA, and the disruption of overall cell metabolism. This silver ion interaction with cytoplasmic structures is nonspecific and can affect many vital cellular functions. For this reason, the use of silver ions in therapeutic scenarios has sometimes been referred to as a "shot gun" approach.

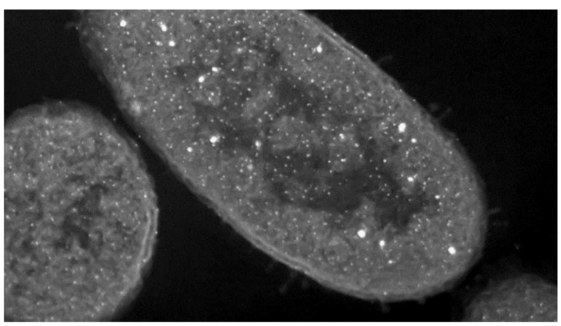
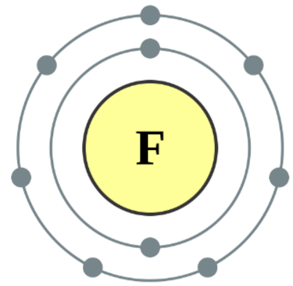


Image of silver particles inside bacterial cytoplasm.

The *Zombie Effect* is an interesting phenomenon that has recently been reported in the literature (*Silver turns bacteria into deadly zombies, 2015*). When a bacterial cell has been inactivated by silver ions, the cell disintegrates, releasing the silver ions back into the environment thus allowing them to cause the death of new bacterial cells that they encounter.

The question of whether silver ions interact with tooth structure in some way that may make the tooth more resistant to acid challenge or may affect bacterial cell attachment are two interesting research question which requires further scientific investigation.

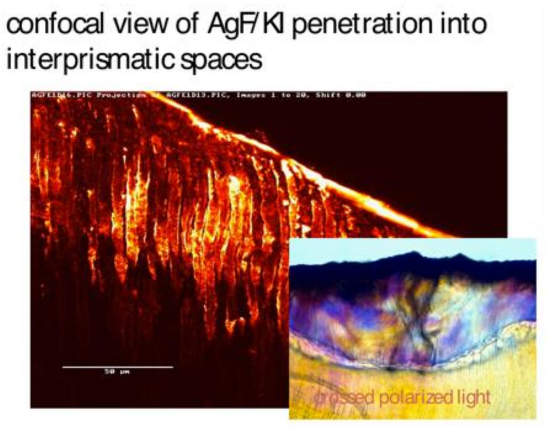
Fluoride



Fluoride is well known to be the most reactive of all the elements in the periodic table. This property may be due to the neutral atom having one missing electron in its outer electron energy shell. Fluoride tends to attract an electron from neighboring elements in chemical reactions. This results in a negative ionic state charge (Fl-).

The mode of action of fluoride in protecting teeth from demineralization has been well studied. It is not the intent of this text to fully cover this literature. The conversion of hydroxyapatite to fluorapatite in enamel protects the tooth structure during an acid challenge. A robust exploration of this subject should be sought elsewhere.

It is worth noting that the two major elements present in SDF are highly reactive due to the configuration of their outer electron shells. The tendency of Ag+ to react with Fl- and form a salt is counteracted by the presence of ammonia in SDF solutions. This means that the silver and fluoride ions remain in solution enhancing their bioavailability for interaction with the bacterial cells and with tooth structure. How these properties of electron shell structures translate into clinical outcomes remains another opportunity for further investigation at this time.



This image above was created by Dr. Geoffery Knight and is presented here with his permission. It is significant in that it is an early illustration showing the presence of silver ion in the interprismatic space of intact enamel following topical SDF application.

Silver ions may penetrate the enamel surface and access the interprismatic spaces, where they become bound to the protein matrix or hydroxy-appetite crystals of the tooth. This reservoir of silver provides for substantivity and Ag+ ions may be able to migrate out onto the tooth surface where they either alter the development of the enamel pellicle or alter the attachment sequence of early colonizing bacteria. The significant result is hypothesized to be the failure of the development of a pathologic biofilm on the tooth surface and thereby demonstrating the bactericidal efficacy of the silver ion. Such a hypothesis needs vigorous scientific investigation prior to making any claims about its accuracy.

References

Silver turns bacteria into deadly zombies. (2015, May). Silver turns bacteria into deadly zombies. from Science | AAAS website: http://www.sciencemag.org/news/2015/05/silver-turns-bacteria-deadly-zombies

Silver Nitrate and Silver Diamine Fluoride

(Dr. Steve Duffin, DDA and Marcus Duffin, MS, MBA)

We now understand that the medical management of caries using silver ion compounds began with the introduction of silver nitrate in the 19th century. SDF was described in 1972 by Yamaga and Nishino and has been used widely around the world but was unavailable in the United States until 2016. This author (SD) developed a combination protocol using silver nitrate and fluoride varnish described in the Journal of the California Dental Association November 2012 (*Duffin, 2012*) (*Gao S et al., 2016*). After more than 60 years on the market in many countries, there have been ***no adverse events*** reported in the literature with the use of silver diamine fluoride**.** (*personal communication Dr. Edward Lo*). Systematic reviews of clinical trials using this product show very high success rates, although no definitive application protocol has yet been identified (*Gao SS et al., 2016*). As of 2018, the controversy in the dental profession regarding the use of silver ion products in controlling caries has settled down and is currently being discussed as the new "Gold Standard" for caries management (Milgrom et al., 2018).

Adverse Effects of Silver and Fluoride Compounds

Staining of Tooth Structure

Silver ion compounds *do not stain* normal healthy enamel. Silver ions *do* react with demineralized tooth structure forming silver oxide and silver sulfate compounds, which appear dark in color. An early use of silver nitrate was as a caries detector. One of the primary identifying characteristics of arrested caries lesions is a dark color. This phenomenon has proven helpful in determining success of treatment and it is suggested that parents and patients be fully informed of this possible color change that occurs after treatment with silver ion compounds.

A dark arrested lesion is not an adverse side effect. It is the intended outcome of caries detection and caries arrest using silver ion compounds.

Arrested decay - Dr. Duffin.

Some clinicians refer to this dark arrested lesion as a *scar*. When explained to patients that a tooth cavity is caused by an infection on the tooth surface and that placing medicine (silver ion compound) on that surface, the infection is stopped, but a scar remains, patients usually understand this simple explanation rather well. If the remaining stain of the arrested lesion produces an unwanted aesthetic result, it is possible to cover the arrested lesion with a glass ionomer, an opaquing agent, or to place a conventional restoration. ***Due to the desensitizing effect of silver ion compounds, it is often possible to place a restoration without the***

need for local anesthesia. Children who are fearful of injections rarely object to this possibility.

Silver ion products turn caries lesions a dark color during the antimicrobial arrest process. Silver nitrate and SDF **do *not stain*** normal healthy enamel. Regardless of color change, silver ion compounds are being used as a disinfection agent to kill the bacteria that cause tooth decay. This process was clearly described by G. V. Black in 1908. Silver ion compounds were used historically and continue to be used as a caries detection agents. Silver ions form bonds with various organic compounds in tooth structure that appear dark in color.

The ability for silver ion compounds to act as both a tool for caries detection and as an antimicrobial agent is remarkable.

This feature will enable oral health providers to render care for at risk populations without the limitation to “diagnose caries”. The final diagnostic step can be scheduled at such time as a dentist may participate either directly or via tele-health technology and develop a restorative treatment plan with the patient. Infection control and restorative interventions are separate considerations. Such a combination of technology and workforce development could greatly enhance the access of many global populations to oral healthcare services.

Staining of Skin

The next photo is the authors hand four days after handling Silver Diamine Fluoride without proper gloving. Note the slight residual stain on the palm. As the outer layers of epidermis exfoliate naturally, the dead skin cells that have been stained with silver are lost, as is the stain. Accidentally exposing the skin to silver ion products can cause a temporary stain. Exposure to light enhances the temporary darkening effect of the silver on the skin.

Temporary skin stain photo courtesy of Dr. Duffin.

Patient Safety

Silver ion compounds will temporarily stain skin and mucosa and permanently stain fabrics and other surfaces. Care must be taken to protect exposed skin and mucosa from the temporary staining of silver ion compounds. This includes careful application technique and wearing gloves. Placing a thin layer of Vaseline on the lips of a patient prior to placement of silver ion products may reduce the chances for inadvertent staining. Care must be taken not to place Vaseline on the lesion to be treated.

Eyewear protection.

Special care must be taken to protect the eyes from accidental exposure to silver ion products. This is accomplished by simply wearing sunglasses during application.

Argyria

(This sub-section written by Jacqueline Juhl)

A well-known side effect of systemic exposure to *large* quantities of silver ion is a condition known as argyria. This is characterized by a distinct blue color change to the skin and is permanent. Most of the cases reported in the literature come from industrial exposure or from intentional ingestion of silver nitrate. The "Blue Man" story is an interesting historical example (*Eun Kyung Kim, 2013*)

Although a color change to the skin occurs in argyria, no other toxic effects have been found. *MMC protocols utilize a very small amount of free silver ion that has been shown to be toxic to bacteria and not to humans.* Argyria is a rare condition associated with chronic exposure to silver-containing products. It involves the deposition of metallic silver granules in the skin, mucous membranes, and internal organs including the central nervous system. In skin, silver is primarily deposited around adeposal structures in the dermis; it is associated with a bluish-gray to slate-gray hue. This discoloration is thought to result from the presence of silver and a silver-induced increase in melanin concentration. The effect is most pronounced in sun-exposed areas such as the face, neck, arms, and dorsum of the hands, but it can also be seen in fingernails (azure lunulae), conjunctival membranes, and oral mucosa. The pigment that is deposited is usually silver sulfide, formed by the conversion of silver salts in the presence of light and sulfur-containing organic matrix (in the form of amino acids). The silver sulfides thus formed have a stimulatory effect on melanin synthesis. Discoloration is more proportional to the total metal dose than to the amount of sun exposure. The route of administration determines the generalized or localized nature of argyria.

The differential diagnosis for argyria includes methemoglobinemia, polycythemia, Addison disease, Wilson disease, carcinoid syndrome, hemochromatosis, and ingestion of certain compounds (antimalarials, minocycline, amiodarone, chlorpromazine) or other metals (gold, mercury, and bismuth). With the exception of a case report associating argyria with a convulsive seizure disorder, no physiologic alteration or organ damage has been reported in cases of tissue deposition of silver ion. Argyria is a rare condition, and unfamiliarity with this disorder has resulted in the clinical presentation being misdiagnosed as cyanosis, leading to invasive, expensive, and unnecessary diagnostic procedures. Silver deposition and hyperpigmentation of the skin in argyria is permanent and primarily of cosmetic significance, and it has no effective treatment. It is very unlikely that agyria might result from conservative use of silver compounds in the medical management of caries (*Moran, 2013*) (*Wadhera & Fung, 2019*).

References

Duffin, S. (2012). Back to the future: the medical management of caries introduction. Journal of California Dental Association, 40(11), 852–858.

Eun Kyung Kim. (2013, September 24). Real-life "Blue Man" dies after heart attack, stroke. From TODAY.com website: https://www.today.com/health/real-life-blue-man-dies-after-heart-attack-stroke-4b11243410

Gao, S. S., Zhao, I. S., Hiraishi, N., Duangthip, D., Mei, M. L., Lo, E. C. M., & Chu, C. H. (2016a). Clinical Trials of Silver Diamine Fluoride in Arresting Caries among Children. JDR Clinical & Translational Research, 1(3), 201–210. https://doi.org/10.1177/2380084416661474

Gao, S., Zhao, I., Duffin, S., Duangthip, D., Lo, E., & Chu, C. (2018). Revitalizing Silver Nitrate for Caries Management. International Journal of Environmental Research and Public Health, 15(1), 80. https://doi.org/10.3390/ijerph15010080

Milgrom, P., Horst, J. A., Ludwig, S., Rothen, M., Chaffee, B. W., Lyalina, S., … Mancl, L. (2018). Topical silver diamine fluoride for dental caries arrest in preschool children: A randomized controlled trial and microbiological analysis of caries associated microbes and resistance gene expression. Journal of Dentistry, 68, 72–78. https://doi.org/10.1016/j.jdent.2017.08.015

Moran, L. (2013). Man who turned blue after taking silver for skin condition dies. From Nydailynews.com website: http://www.nydailynews.com/news/national/man-turned-blue-silver-dies-article-1.1466905

Wadhera, A., & Fung, M. (2019). Systemic argyria associated with ingestion of colloidal silver. Dermatology Online Journal, 11(1). Retrieved from http://www.escholarship.org/uc/item/0832g6d3

FDA Warning About Sedation and General Anesthetics

(Dr. Steve Duffin, DDS and Marcus Duffin, MS, MBA)

Concerns about the potential neurotoxic effect of general anesthetics and sedation drugs in young children has been accumulating since the 1990's. In December of 2016 a warning announcement was released by the FDA for many of these drugs.

FDA Drug Safety Communication: FDA approves label changes for use of general anesthetic and sedation drugs in young children

This is an update to the FDA Drug Safety Communication: FDA review results in new warnings about using general anesthetics and sedation drugs in young children and pregnant women (/Drugs/DrugSafety/ucm532356.htm) issued on December 14, 2016.

Safety Announcement

[4-27-2017] The U.S. Food and Drug Administration (FDA) is notifying the public that we have approved previously announced label changes regarding the use of general anesthetic and sedation medicines in children younger than 3 years. These changes include:

Given this new level of scrutiny about safety, a very careful process should ensue prior to making the decision to subject a young child to the risks of sedation and or general anesthesia in conjunction with dental treatment.

As we begin to question some of the pharmacological methods used to obtain cooperation from young children during dental restorative treatment, we have witnessed the arrival of silver ion and SMART methods for providing clinical care using a *medical*, *less invasive, and less traumatic,* **nonsurgical** approach. These complementary events are a great benefit to both practitioners and patients. In a case report in 2012, this author described a dramatic decrease in the number of general anesthesia cases in his practice after implementing medical management of caries principles (*Duffin, 2012*).

References

Duffin, S. (2012). Back to the future: the medical management of caries introduction. Journal of California Dental Association, 40(11), 852–858.

The "Off Label" Use of Drugs and Medical Devices in the US

(Dr. Steve Duffin, DDS and Marcus Duffin, MS, MBA)

The discussion of this subject is prompted by the path of silver diamine fluoride (SDF) through the FDA approval process and toward commercial availability in the United States.

Please visit the www.mmclibrary.com site and activate the main page FDA button to listen to a thirty-five-minute presentation by Dr's Shirtcliff and Milgrom on how SDF was cleared by the FDA.

- http://www.mmclibrary.com/SDF_-_FDA_Status.html

We do not claim to be an expert in the complex working processes of the FDA, however we have spoken at length with many experts and believe that we understand the basic path to approval that has taken place for this product. With gratitude, we wish to thank the individuals and organizations that committed many years and resources to make this outcome possible.

In 2005, I (SD) became sufficiently interested in the potential of SDF to benefit my patients in a high caries risk population in Keizer, Oregon. The product was not available at the time in the USA, so I contacted a colleague in Japan who purchased a bottle of Saforide from J. Mortia corporation and sent it to me. I had read much of the literature existing at the time about the products use and was confident of its safety and potential for controlling caries. I began introducing SDF into my practice. In a very short time period, I was amazed by the products ability to arrest tooth decay and a seeming reduction of new decay in patients that I treated. However, I was frustrated with the difficulty in obtaining the SDF product. I also was fortunate enough to receive a separate sample of silver fluoride from Dr. Graham Craig in Australia. I was aware that a group of SDF advocates in the United States were working on obtaining FDA approval to clear the product to market, however we had to wait ten years for this to happen. The usual pathway for introducing a new drug into the US via FDA approval is a laborious and very expensive process. The individuals who supported this SDF process chose to submit SDF as a medical device using fluoride varnish as the predicate. In 2015, the decision at that time seemed to be based on feasibility and resources which then resulted in successful product registration as the specific product, *Advantage Arrest*, as a medical device and as a fluoride product for desensitization. It is worth noting that a similar process had been followed to introduce fluoride varnishes several decades earlier. Fluoride varnishes are approved as a desensitization agents and cavity liners. However, the primary use of the product is in caries management.

Whenever fluoride varnish is used in this way, it is being used "**off label**". There may be some concerns by clinicians using a commercially available product in an off-label manner. Nonetheless, it is important to note that this is an extremely common practice in dentistry and medicine. The clinician should obtain a proper informed consent from the patient when using SDF as would be the case with any medication. The vast majority of the scientific literature about the use of SDF is in caries management. At the time of publication of this manuscript, SDF used in the US in this manner, is being applied "off label". Understanding this fact is important and should be measured against the benefits to patients.

Patient Education and Consent Forms for SDF Treatment

(Dr. Steve Duffin, DDS and Jacqueline Juhl, RDH, BS, MS)

For the benefit of the reader, the following is the consent form developed by the UCSF Paradigm Shift Committee, published in the California Dental Association Journal, January 2016, and included here with permission. This form is also available in multiple languages

- https://sites.google.com/site/jeremyahorst/sdfconsents

UCSF DENTAL CENTER INFORMED CONSENT FOR SILVER DIAMINE FLUORIDE

Facts for consideration:

- Silver Diamine Fluoride (SDF) is an antibiotic liquid. We use SDF on cavities to help stop tooth decay. We also use it to treat tooth sensitivity. SDF application every 6-12 months is necessary.
- The procedure: 1) Dry the affected area, 2) Place a small amount of SDF on the affected area, 3) Allow SDF to dry for one minute, 4) Rinse.
- **Treatment with SDF does not eliminate the need for dental fillings or crowns to repair function or esthetics. Additional procedures will incur a separate fee.**
- I should not be treated with SDF if: 1) I am **allergic to silver** 2) there are painful sores or raw areas on my gums (i.e., ulcerative gingivitis) or anywhere in my mouth (i.e., stomatitis).

Benefits of receiving SDF:

- SDF can help stop tooth decay.
- SDF can help relieve sensitivity.

Risks related to SDF include, but are not limited to:

- **The affected area will stain black permanently.** Healthy tooth structure will not stain. Stained tooth structure can be replaced with a filling or a crown.
- Tooth-colored fillings and crowns may also discolor if SDF is applied to them. Normally this color change is temporary and can be polished off.
- If accidentally applied to the skin or gums, a brown or white stain may appear that causes no harm, cannot be washed off, and will disappear in 1-3 weeks.
- You may notice a metallic taste. This will go away rapidly.
- If tooth decay is not arrested, the decay will progress. In that case the tooth will require further treatment, such repeat SDF, a filling or crown, root canal treatment, or extraction.
- These side effects may not include all of the possible situations reported by the manufacturer. If you notice other effects, please contact your dental provider.
- Every reasonable effort will be made to ensure the success of SDF treatment. There is a risk that the procedure will not stop the decay and no guarantee of success is granted or implied.

Alternatives to SDF, not limited to the following:

- No treatment, which may lead to continued deterioration of tooth structures and cosmetic appearance. Symptoms may increase in severity.
- Depending on the location and extent of the tooth decay, other treatment may include placement of fluoride varnish, a filling or crown, extraction, or referral for advanced treatment modalities.

I CERTIFY THAT I HAVE READ AND FULLY UNDERSTAND THIS DOCUMENT, AND ALL MY QUESTIONS WERE ANSWERED:

______________________________(signature of patient) ____________________(date)

______________________________(signature of witness) ____________________(date)

The following two images are another example of an SDF information form for patient education developed by Kelly Matthews, RDH in 2014, Salem, Oregon.

Medical Management of Caries: Silver Diamine Fluoride

Silver Diamine Fluoride is an antimicrobial treatment for the infection that causes tooth decay and for the reduction in tooth sensitivity. Silver Diamine Fluoride has been used extensively in numerous countries around the globe for decades and is FDA approved.

Benefits of Silver Diamine Fluoride

- Provides pain relief
- Stains visible & hidden tooth decay
- Provides relief for sensitive teeth
- Plaque management
- Helps prevent decay caused by dry mouth
- Offers a No Needle/No Drill alternative treatment

Just a scar

Why Choose Silver Diamine Fluoride

- Diagnostic tool for cavity detection
- Strengthens teeth making them more acid and abrasion resistant
- Tooth is healed STOPPING the spread of disease
- No known side effects other than staining of carious tooth structure
- Provides cost benefits for children and adults

What it looks like

Tooth Scaring

How does it work?

Silver Diamine Fluoride is a potent antimicrobial agent used to kill germs that cause cavities. The free silver ion from Silver Diamine Fluoride is absorbed into the bacterial cell and disrupts cellular metabolism which kills the bacteria. When applied to a tooth with a possible cavity, active caries lesions become inactive and the risk of future decay is reduced. Providing important clinical feedback due to its potential to stain visible and hidden lesions.

How do I know it is working?

The *scar* caused by the cavity is turned black by the Silver Diamine Fluoride. When this occurs, the dark surface becomes hard to gentle probing. This also reduces sensitivity to hot, cold, and sweets. Most importantly, an arrested cavity does not grow in size. Data on this procedure suggests that when all active cavities become inactive, there is a reduced chance of new cavities developing.

Who will benefit from this treatment?

Everyone can benefit from the treatment of Silver Diamine Fluoride. Children can have a no needle/no drill treatment to save baby teeth for eating, speaking, smiling and keeping place holders for permanent teeth. Adults can manage treatment over time, particularly when dealing with multiple areas of decay. As Sliver Diamine Fluoride slows or even stops decay from progressing allowing patients the ability to manage appointment time and expense of future restorative work. Provides a stop gap method of care for frail seniors and physically or mentally challenged patients that can prevent expensive hospital visits while improving quality of life. This treatment can also help manage the side effects of dry mouth caused by increased medication.

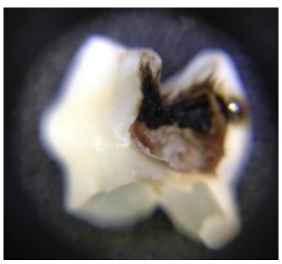
"The important thing is having an antimicrobial step to control and arrest the caries prior to entering a restorative phase."

-Dr. Steven Duffin, D.D.S.

Treatment Failures: What Happened ?

(Dr. Steve Duffin, DDS)

When I began to use SDF in 2006, I was amazed at how effective it was in arresting tooth decay. There was little written in the literature at that time about application protocols. After six months of success, I started to have a few failures. Lesions that seemed to be arrested on the surface of the tooth became abscessed. I became so discouraged that I almost gave up SDF treatments. After some thought, I decided to section the extracted teeth and examine them microscopically to see what I might discover.



Images provided by Dr. Steve Duffin.

What I found was that the superficial areas of the decay appeared to be dark and arrested, but the deeper aspects of the lesion seemed to be unaffected and probably were still active. As I pondered why this situation had developed, it occurred to me that perhaps the silver ion solution had been unable to diffuse completely into the lesion. This might have been due to dilution from saliva, or perhaps I needed to apply SDF multiple times.

Empirically, I changed my application protocol to include:

1. *isolation and debridement*
2. *careful air drying of the lesion*
3. *application of silver ion compound*
4. *immediately covering with fluoride varnish in order to protect the treated lesion. I repeated this treatment at 2, 4, 8, and 12 weeks.*

When I began following this new MMC application protocol, the failures dramatically decreased. I began to see most of the primary teeth treated in this way *survive until exfoliation*. Presently, (2018), I am more likely to apply SDF+FV two or three times over several weeks, confirm arrest by color and surface hardness and then cover the lesion with a glass ionomer cement, the SMART technique. The optimum application protocol awaits discovery.

Smart arrest and restore/protect with GIC.

The ability to collapse this technique into one step as some clinicians are doing is interesting, but confirmation of similar outcomes between the methods awaits confirmation in clinical trials.

Clinical Trials of Silver Diamine Fluoride for Management of Caries in Preschool Children

(Dr. Sherry Shiqian Gao, BDS, MSc, PhD and Dr. Chun Hung Chu, BDS, MDS, PhD)
Faculty of Dentistry, The University of Hong Kong

Hong Kong University Caries Research Group.

It is with great appreciation that I introduce this section by the Hong Kong 'group. This team of scientists have been working on the question of silver ion compounds in caries management for many years. Numerous scientific papers of the highest quality have been produced and additional work is presently underway. Those of us that are working in this field remain deeply indebted to the great work of this fine group.
-Dr. Steve Duffin

Although peoples' dental knowledge has improved and dental treatment techniques have advanced over the past few decades, early childhood caries remains a global health problem. In Hong Kong, more than half of 5-year-old children suffer from early childhood caries, and almost all (93%) dental caries has been left untreated (*Chen et al., 2017*). Studies reported that adverse socioeconomic conditions, such as poor parental education and low family income, are risk factors related to early childhood caries in Hong Kong preschoolers (*Chen et al., 2017*)

(*Gao et al., 2018a*). Therefore, conventional restorative treatment for early childhood caries is often neither available nor affordable for children with high caries risk. In addition, cooperation from young children during dental treatment is a major challenge for dentists. Hence, alternative treatments, which should be low cost, simple and non-invasive, are needed (*Gao et al., 2018b*).

Silver diamine fluoride (SDF) has been used to arrest dental caries in young children since the 1960s (*Nishino, 1969*). It can be used as a non-invasive protocol with minimum instruments and time required. The Faculty of Dentistry, the University of Hong Kong (HKU Faculty of Dentistry) began to conduct research on SDF at 1998.

The research was held in two aspects: first, laboratory studies aimed at investigating the remineralizing and anti-bacteria effects of SDF on dental hard tissues and biofilms, and second, clinical studies exploring the clinical effect of SDF in arresting early childhood caries in preschool children as well as root caries in elders. In this chapter, we summarize the findings of clinical studies on SDF for caries arrest in preschoolers in Hong Kong. The details of the methodology and main results are summarized in Table 1.

SDF vs Other Topical Interventions

Among five clinical trials, four studies included other topical interventions for caries management as comparisons (*Chu et al., 2002*) (*Duangthip et al., 2018b*) (*Gao et al., 2018c*) (*Zhi et al., 2012*).

Chu et al. reported that an annual application of a 38% SDF solution was more effective than that of a 5% sodium fluoride (NaF) varnish for arresting dental caries in anterior teeth, whereas no significant difference was found regarding the caries-arresting effect between 5% NaF and water (as a negative control) (*Chu et al., 2002*). However, when applied weekly for three times at baseline, 30% SDF did not show a superior effect to that of 5% NaF in arresting both cavitated and non-cavitated caries at 30-month follow-up (*Duangthip et al., 2018b*).

Glass ionomer cement has been used as the material for restorative treatments, mostly for caries in the primary dentition, and fissure sealants for children. A randomized clinical trial reported that an annual application of 38% SDF had a similar effect as glass ionomer cement regarding caries arrest (*Zhi et al., 2012*).

Apart from SDF, another silver compound, silver nitrate, has also been understudied. Dr. Duffin introduced a protocol for caries management by using silver nitrate conjointly with NaF varnish (*Duffin, 2012*). A laboratory study by the HKU Faculty of Dentistry reported that a combined application of a 25% silver nitrate solution followed by a 5% NaF varnish could enhance the remineralization of carious dentine and avoid the degradation of collagen (*Zhao et al., 2017*). As no clinical study on using a 25% silver nitrate solution followed by a 5% NaF varnish for caries arrest had been conducted, two ongoing randomized clinical trials were conducted to investigate the effectiveness of this protocol (*Chen et al., 2018*) (*Chu et al., 2015*). The results of Gao et al.'s study indicated that a 25% silver nitrate solution followed by a 5% NaF varnish was not worse than a 38% SDF solution for caries arrest when applied twice a year (*Gao et al., 2018c*).

In general, we can conclude that:

1. 38% SDF has a similar caries-arresting effect as glass ionomer cement;

2. 38% SDF has a similar caries-arresting effect as a combined application of 25% silver nitrate followed by 5% NaF;

3. 5% NaF alone is not effective for caries arrest;

4. The baseline application of 30% SDF is not superior to that of 5% NaF in arresting early childhood caries.

Recommended Protocol for Clinical Application of SDF

Various treatment application protocols were adopted in five clinical trials. Chu et al. demonstrated that carious tissues did not need to be removed before the application of a 38% SDF solution (*Chu et al., 2002*). Three studies investigated the relationship between the caries-arresting effect and the frequency of the intervention application. Duangthip et al. reported that an annual application of 30% SDF was more effective than a baseline application of 30% SDF (*Duangthip et al., 2018b*). Both Zhi et al. and Fung et al. found that a semi-annual application of 38% SDF was superior to an annual application in arresting early childhood caries (*Fung et al., 2018*) (*Zhi et al., 2012*). Regarding the concentration of the SDF solution, one study reported that a high concentration of SDF (38%) was more effective than a low concentration of SDF (12%) for caries arrest (*Fung et al., 2018*).

Therefore, the recommended protocol for the clinical application of SDF can be summarized as follows:

1. Caries removal before an SDF application offered no additional long-term benefit in caries arrest;

2. Increasing the application frequency can lead to a better outcome of caries arrest;

3. A high concentration of SDF is more effective compared with a low concentration in arresting early childhood caries.

Confounding Factors Related to Caries-Arresting Effect

According to the main finding of these clinical studies, caries-arresting outcomes can be related to the application protocol we chose. However, we cannot neglect the effect of confounding factors that may be related to the success of treatments. All five studies conducted analyses to identify the confounding factors. We would like to classify the factors into the follow categories:

The positions of the carious lesions

Four out of five studies reported that carious lesions on buccal surfaces had a higher chance of becoming arrested (*Duangthip et al., 2018b*) (*Fung et al., 2018*) (*Gao et al., 2018c*) (*Zhi et al., 2012*). Referring to cavitated dentine caries, most of the studies found that carious lesions in the anterior teeth had a better outcome with regard to caries arrest (*Duangthip et al. 2018b*) (*Fung et al., 2018*) (*Gao et al., 2018c*) (*Zhi et al., 2012*). Referring to non-cavitated caries, one study reported that carious lesions on the posterior teeth presented a better caries-arresting outcome (*Duangthip et al., 2018b*).

The sizes of the carious lesions

The results of two studies revealed that the larger the sizes of the carious lesions, the lower the chance of the carious lesions becoming arrest (*Duangthip et al., 2018b*) (*Fung et al., 2018*).

Caries experience

Studies revealed that baseline caries experience (*Chu et al., 2002*), caries experience at follow-up examination (*Duangthip et al., 2018b*), and newly developed caries at follow-up examination (*Gao et al., 2018c*) were negatively associated with the caries-arresting outcome.

Oral hygiene

Oral hygiene is also an important confounding factor related to the effectiveness of topical silver compound treatment. Two studies reported that the higher the visible plaque index score at follow-up examination, the lower the chance that the caries will become arrested (*Fung et al., 2018*) (*Gao et al., 2018c*). In addition, studies revealed that the presence of plaque on the treated carious lesions decreases the chance of caries arrest (*Duangthip et al., 2018b*) (*Fung et al., 2018*).

Oral health-related behaviors

One study reported that caries had a higher chance of becoming arrested if children had regular tooth-brushing behavior.

To conclude, carious lesions in the anterior teeth or on buccal surfaces, and smaller carious lesions will have higher chances of becoming arrested following topical SDF treatment. Children with lower caries experience, better oral hygiene statuses, and better oral health-related behaviors will have higher chances of having their caries become arrested.

Adverse Effect and Parental Satisfaction of Silver Compound Application

All five studies reported that black staining on carious lesions following treatment was a major side effect of applying silver compounds. No other severe adverse effect was observed (*Chu et al., 2002*) (*Duangthip et al., 2018b*) (*Fung et al., 2018*) (*Gao et al., 2018c*) (*Zhi et al., 2012*).

To provide more detailed information of the adverse effects, based on the study by Fung et al., parental questionnaires regarding the presence of side effects were collected one week after the treatment application (*Duangthip et al., 2018a*). The results showed that no acute systemic illness was reported by parents. Black staining following treatment was observed on most of the carious lesions. Nevertheless, parental satisfaction with their children's dental appearance improved at the follow-up examinations. Referring to local side effects other than black staining, tooth/gum pain, gum swelling, and gum bleaching were observed by some parents. However, the prevalence of the side effects was low (ranging from 2.8% to 6.6%). In addition, no significant difference was found regarding the presence of local side effects among four treatment groups (12% SDF annually, 12% SDF semi-annually, 38% SDF annually, and 38% SDF semi-annually).

The HKU Faculty of Dentistry has been studying silver compounds for caries arrest for two decades. According to the clinical studies done in Hong Kong, 38% SDF is effective in arresting early childhood caries, which is consistent with the results generated by a systematic review and meta-analysis (*Gao et al., 2016*). Using a high concentration of SDF and increasing the application frequency can lead to a better outcome of caries arrest. The tooth and surface locations of carious lesions, the sizes of the carious lesions, and the children's caries experience, oral hygiene statuses, and oral health-related behaviors are associated with the caries-arresting outcome. Black staining is a major side effect of silver compound application, together with tooth/gum pain, gum swelling, and gum bleaching. However, the prevalence of the latter three side effects is low. No acute systemic disease has been reported following treatment. Therefore, according to the Hong Kong clinical studies, we can conclude that topical silver compounds treatment (mainly SDF solution) is an effective, simple and non-invasive approach to managing early childhood caries. The treatment protocol is valuable for young children, particular those from low-socioeconomic and disadvantaged families.

Authors Year	Methods	Caries-arresting effect	Confounding factors related to caries-arresting outcome	
			+ Positive associated	– Negative associated
Chu et al. 2002	3- to 4-year-old children (N=375) 30-month follow-up Gp1 – 38% SDF + excavation annually Gp2 – 38% SDF annually Gp3 – 5% NaF + excavation every 3 months Gp4 – 5% NaF every 3 months Gp5 – Water	Gp1,2 > Gp3,4,5	Tooth-brushing behavior	Baseline caries experience
Zhi et al. 2012	3- to 4-year-old children (N=212) 24-month follow-up Gp1 – 38% SDF annually Gp2 – 38% SDF semi-annually Gp3 – GIC annually	Gp2 > Gp1,3	Anterior teeth Buccal or lingual lesions	
Duangthip et al. 2018	3- to 4-year-old children (N=371) 30-month follow-up Gp1 – 30% SDF annually Gp2 – 30% SDF weekly*3 at baseline Gp3 – 5% NaF weekly*3 at baseline	Non-cavitated lesions: Gp1=Gp2=Gp3 Cavitated lesions: Gp1 > Gp2,3	Non-cavitated lesions: Posterior teeth Buccal or lingual lesions Cavitated lesions: Anterior teeth Buccal or lingual lesions	Non-cavitated lesions: Size of carious lesions 30-month caries experience Plaque on the carious lesions Cavitated lesions: Plaque on the carious lesions
Fung et al. 2018	3- to 4-year-old children (N=888) 30-month follow-up Gp1 – 12% SDF annually Gp2 – 12% SDF semi-annually Gp3 – 38% SDF annually Gp4 – 38% SDF semi-annually	Gp4 > Gp3 > Gp2 > Gp1	Anterior teeth Buccal or distal lesions	Size of carious lesions Plaque on the carious lesions VPI score
Gao et al.	3- to 4-year-old children (N=1,070)	Gp1 = Gp2	Anterior teeth	Newly developed caries

Table 1: Summary of clinical studies of silver compounds for arresting early childhood caries in preschoolers in hong kong . (Gp, Group; SDF, Silver Diamine Fluoride; NaF, Sodium Fluoride; GIC, Glass Ionomer Cement; ICDAS, International Caries Detection and Assessment System).

References

Chen KJ, Gao SS, Duangthip D, Li SKY, Lo ECM, Chu CH. 2017. Dental caries status and its associated factors among 5-year-old Hong Kong children: A cross-sectional study. BMC oral health. 17(1):121.

Chu CH, Lo ECM, Lin H. 2002. Effectiveness of silver diamine fluoride and sodium fluoride varnish in arresting dentin caries in Chinese pre-school children. Journal of Dental Research. 81(11):767-770.

Duangthip D, Fung MHT, Wong MCM, Chu CH, Lo ECM. 2018a. Adverse effects of silver diamine fluoride treatment among preschool children. Journal of Dental Research. 97(4):395-401.

Duangthip D, Wong MCM, Chu CH, Lo ECM. 2018b. Caries arrest by topical fluorides in preschool children: 30-month results. Journal of Dentistry. 70:74-79.

Fung M, Duangthip D, Wong MCM, Lo ECM, Chu CH. 2018. Randomized clinical trial of 12% and 38% silver diamine fluoride treatment. Journal of Dental Research. 97(2):171-178.

Gao SS, Zhao IS, Hiraishi N, Duangthip D, Mei ML, Lo ECM, Chu CH. 2016. Clinical trials of silver diamine fluoride in arresting caries among children: A systematic review. JDR Clinical & Translational Research. 1(3):201-210.

Gao SS, Duangthip D, Lo ECM, Chu CH. 2018a. Risk factors of early childhood caries among young children in Hong Kong: A cross-sectional study. Journal of Clinical Pediatric Dentistry. 42(5):367-372.

Gao SS, Zhao IS, Duffin S, Duangthip D, Lo ECM, Chu CH. 2018b. Revitalizing silver nitrate for caries management. International Journal of Environmental Research and Public Health. 15(1):80.

Gao SS, Duangthip D, Lo ECM, Chu CH. 2018c. Silver nitrate with sodium fluoride for caries arrest: 18-month results. [Abstract] Journal of Dental Research 97(Spec Iss B): SC1280 (www.iadr.org).

Nishino M. 1969. Effect of topically applied ammoniacal Silver Diamine Fluoride on dental caries in children. Journal of Osaka University Dental School. 9:149-155.

Zhi QH, Lo ECM, Lin HC. 2012. Randomized clinical trial on effectiveness of silver diamine fluoride and glass ionomer in arresting dentine caries in preschool children. Journal of Dentistry. 40(11):962-967.

Glass Ionomer Cement as a Chemical Treatment for Caries

(Dr. Douglas A. Young, DDS, EdD, MS, MBA and Dr. Allen Wong, DDS, EdD)

Dental caries is a multifactorial disease that remains a significant problem across all age groups. *("Surveillance for Dental Caries, Dental Sealants, Tooth Retention, Edentulism, and Enamel Fluorosis --- United States, 1988--1994 and 1999--2002," 2019*) A chronic and progressive disease, a caries lesion is the end result of the disease itself and will result if *demineralizing* pathogenic factors that are allowed to overcome the protective factors in the oral cavity (*Young & Featherstone, 2013*) (*Featherstone, 2006*). For over two decades, science has been suggesting an alternative paradigm to "drill and fill" dentistry which does little to treat the causative factors of the disease process. Caries management by risk assessment (CAMBRA) or other evidence-based caries risk assessment instruments (eg: ICDAS) have emerged as an evidence-based strategy that uses the patient's unique caries risk profile to prevent, reverse and, when necessary, repair damage to teeth using tooth preserving methodologies (*Young et al., 2007*). To effectively arrest, reverse, and treat all aspects of caries lesions (non-cavitated and cavitated) the more precise ADA Caries Classification System (ADA CCS) terminology was established to evaluate on the site, extent, and activity of the lesion (*Young et al., 2015*).

Although there are several evidence-based caries risk assessment guidelines available, CAMBRA protocols have been published and updated for children and adults (*Ramos-Gomez et al., 2011*) (*Hurlbutt & Young, 2014*) (*Jenson et al., 2007*). These protocols have focused on modifying the patient risk factors using behavioral modification and chemical therapeutic interventions targeted to modifying biofilm and promote chemistry to support remineralization and halt demineralization. Recently, the clinical use of conventional glass ionomer cement (GIC) and emerging chemotherapeutic options such as silver diamine fluoride (SDF) to arrest caries lesions has recently catapulted to the forefront and warrants more focus within the CAMBRA management toolkit. This chapter will suggest how a clinician can utilize conventional GIC in a synergy with the CAMBRA philosophy and SDF to combat caries disease.

History of Acid-Base Cements

The creation of dental cements resulted from clinical use of amalgam, gold, and porcelain in the mid-to-late-1800s. First introduced in 1870, zinc oxide-phosphoric acid cement later evolved to the modern zinc phosphate cement and was

COMPOSITION OF ACID-BASE CEMENTS	**LIQUID** **Phosphoric acid**	**LIQUID** **Polyacrylic acid liquid**
POWDER **Zinc phosphate**	Zinc phosphate cement	Polycarboxylate cement
POWDER **Silicate glass powder**	Silicate cement	Glass-ionomer cement

Table 1: Composition of Acid-Base Cements.

used for cementation, temporary fillings, liners and bases by the turn of the century (*Ames, 1892*) (*Fleck, 1902*). Zinc oxide eugenol was introduced by Pierce and Flagg in 1875. In 1908, a fluoride releasing silicate cement was developed by Schoenbeck (*Smith, 1967*). Because of the high level of fluoride release of silicate cements, there was reported evidence of an anti-caries effect. The three cements that were commonly use in 1925 were zinc phosphate, zinc oxide eugenol, and silicate. However, because of the high solubility of silicate cement, it quickly fell out of favor and the search for its replacement led to the development of polycarboxylate cements. Thirty-eight years later, the next advancement in acid-base cements emerged with the introduction of the first polyacid cement in 1963, zinc polycarboxylate cement, which had the ability to adhere to tooth structure by binding to calcium and hydrogen bonding to collagen (*Leach & Puttnam, 1962*) (*Wall & Drenan, 1951*). A polyacid cement relies on the electrolytic reaction of metal oxides with acidic water-soluble polymers (*Smith, 1967*) (*Smith, 1968*) . Even with its improved physical properties, both zinc phosphate and zinc polycarboxylate cements had esthetics limitations. Silicate cement was the most aesthetic, but it proved to be too soluble. In 1972 glass ionomer cement (GIC) was developed to answer the liabilities of the existing cements (*Wilson & Kent, 1972*). GIC combined silicate glass powder with polyacrylic acid liquid and retained the best properties of both (improved esthetics and adhesion to tooth structure) and provided the clinically significant benefit of fluoride release. Currently, GIC is the only restorative material, which is water-based and has a significant anti-caries effect (*Ngo, Mount, Mc Intyre, Tuisuva, & Von Doussa, 2006*) (*Smales, 2005*). Table 1 is a simplified summary of the composition of acid-base cements.

Preparation Sequencing

The first clinical step in placing GIC is to prepare the surface by removing the biofilm and pellicle from the area with potential contact with the GIC. It is important that the GIC must have intimate contact with tooth mineral on the "activated" surface as *it has no useful chemical reaction to biofilm and pellicle*. This is simply done by cleaning the entire tooth with grey pumice or air abrasion it prior to beginning the procedure. Next, if caries removal is necessary, it should be done in a conservative fashion to preserve tooth structure and promote the health of the pulp. Conservative caries removal has been described using such terms as "partial" or "selective" caries removal to prevent mechanical pulp exposure and protect the health of an asymptomatic vital pulp (*Thompson, Craig, Curro, Green, & Ship, 2008*) (*Ricketts, Kidd, Innes, & Clarkson, 2009*) (*Schwendicke et al., 2016*). This will be discussed in more detail in the *Tooth Preserving Caries Removal* section.

The next step is to remove the smear layer and activate the molecules of calcium and phosphate on the tooth surface of the preparation and surrounding areas. The cleaning and conditioning of the surrounding area deserves further explanation. GIC is placed in bulk and is less viscous than composite. When placed on the moist surface, it may cause some material to flow past containment appliances such as bands and wedges if these are not tightly adapted thus creating "flash". Unlike composite, GIC flash will chemically bond to a clean and prepared tooth surface to promote remineralization and caries protection (see *Clinical Relevance of GIC Chemistry* later in this chapter) (*H. C. Ngo, Mount, Mc Intyre, Tuisuva, & Von Doussa, 2006*). To condition the preparation and surrounding area, follow the manufacturer instructions to use a tooth conditioner liquid which usually contains 20% polyacrylic acid. Phosphoric acid should *never* be used on dentin as a replacement for polyacrylic acid, because this a stronger acid which will remove too much mineral content and leave exposed collagen even if used for only a few seconds. After the surface is activated it must be kept moist. The surface should appear shiny with a thin moisture layer required for proper ionic exchange between tooth and the GIC. The tooth surface and surrounding area should never be desiccated with air, nor should there be excessive water (visible pooled water) in the preparation. Excessive water contamination will prevent proper polysalt gel formation and increase light scattering resulting in an GIC opaque or "milky white" appearance (*Albers, 2002*).

Chemistry of GIC

Early versions of GIC were composed of only two components: liquid polyacrylic acid (polyacid copolymers) dissolved in water, and powdered calcium aluminosilicate. Later, acid accelerators and hardeners were added to the liquid and metals were added to the powders to improve their physical and clinical properties. Today's GIC are more esthetically translucent and continue to improve in strength. There are now multiple offerings some being specifically marketed for posterior class II restorations and others for anterior esthetics. Improvements in chemistry include advances such as more reactive fluoro-alumino-silicate fillers and higher molecular weight polyacrylic acids for increased flexibility and strength. The polyacid acid-base reaction of GIC dissolves the outer surface of the glass particles in the powder releasing metal cations (i.e. Al^{+++}, Ca^{++} or Sr^{++}). The negative charge on the CO-O– end of the polyacid copolymer not only forms ionic bonds which crosslink the cationic glass fillers but also enables an ionic exchange interaction with the activated tooth surface thus forming ionic bonds and adhesion to the calcium and phosphate of the tooth structure (image below).

The polyacids can also form hydrogen bonds with collagen (*Albers, 2002*). Cross-linking during

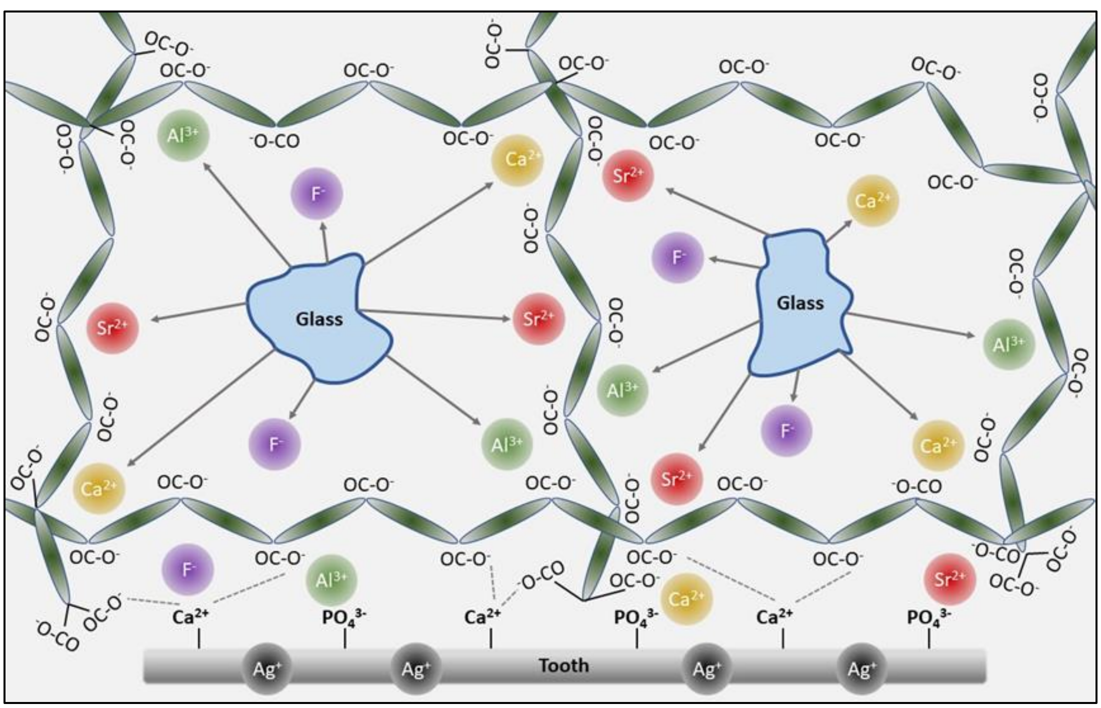


Image courtesy of Marcus Duffin.

the first phase of initial mix and placement is not stable and can be affected by excessive water loss or water gain (*Mount, 2002*). The proper appearance of the GIC surface during this first phase should appear shiny or glossy. At the end of this phase, the surface will start to lose its shine indicating that the free matrix is no longer able to chemically bond. This is a very critical point in clinical placement of GIC. When the gloss begins to disappear from the surface, the clinician must not physically manipulate the GIC. To prevent disruption of gel phase crosslinking, the surface must be protected from further water loss with surface sealant, petroleum coco butter or remoisten with saliva or water. The second phase consists of the poly-acid chains further cross linkage with the trivalent Al ions which reduce solubility and increase physical properties of the solidified GIC (*Mount, 2002*).

Dental Material Selection

Although both are tooth colored, resin-based composite and GIC are completely different. Composite is hydrophobic and micromechanically retained where as GIC is hydrophilic and chemically bonded to the tooth (*Yoshida et al., 2000*). GIC is a material that is biocompatible, has thermal expansion similar to tooth mineral, and is compatible with a moist environment. Resin-based composites rely on UV light initiation to convert monomer to a polymer and the efficiency of conversion is dependent on several factors and will degrade with time. When the resin-based composites are light cured, there is shrinkage and possible contraction gap formation (*Kemp-Scholte & Davidson, 1988*). GIC on the other hand does not rely on conversion of a monomer to a polymer and has no risk of light induced contraction. The liquid already contains the polymer. Once the acid-base reaction has occurred and is chemically bound to the tooth, the cement is very stable over time because ions lost *can* be replenished. If GIC is subjected to acid, surface wear may occur, yet because of the remineralization at the GIC-tooth interphase the margins of GIC will remain chemically sound, acid protected, with less marginal decay than resin-based materials (*H. C. Ngo, Mount, Mc Intyre, Tuisuva, & Von Doussa, 2006*) (*Mickenautsch et al., 2009*) (*Mandari, Frencken, & van't Hof, 2003*). GIC, because of its remineralization chemistry, has been suggested as a chemical delivery device to prevent and treat dental caries rather than solely as a restorative material (*Christensen, 2000*). If dental material selection, specifically glass ionomer, could positively contribute to the management of caries disease from a chemical perspective, it should be considered for caries prone patients with higher caries risk. The clinician should consider stabilizing the tooth with a dental material that provides a good marginal seal, remineralization potential, and caries inhibition effects, while at the same time, focusing on controlling the bacterial infection through chemical and behavioral means.[29]

Clinical Relevance of GIC Chemistry

Unlike resin-based dental materials, GIC is not only hydrophilic but water is an integral part of the restoration itself found at a range of 11-24% (*Mount, 2002*). It is important that this water balance be maintained, not only for placement, but for the life of the restoration. Water is the medium for the dynamic ion exchange process. GIC acts as a reservoir for ions such as fluoride, calcium, strontium, and phosphate needed for remineralization. Studies have demonstrated that the uptake of calcium, phosphate, and fluoride from saliva into the surface of the GIC (*Featherstone, 2006*) and may increase up to two years after which the surface hardness has been shown to approach that of enamel (*Nicholson, 1998*) (*Okada, Tosaki, Hirota, & Hume, 2001*)

(*Van Duinen, Davidson, De Gee, & Feilzer, 2004).* These studies suggest that exposure to ion-rich saliva is clinically advantageous. A key benefit of GIC is the long-term release of fluoride and other ions that support remineralization (*Gorton & Featherstone, 2003*) (*Forsten, 1991*). As these ions are released from the GIC, they can be "recharged" by ions from other sources such as fluoride toothpaste and other sources. The resulting anti-caries properties of GIC restorations was reported in a 2016 Systematic Review by Mickenautsch (*Mickenautsch & Yengopal, 2016*). Other studies have demonstrated less recurrent decay at the cavity preparation margins and adjacent surfaces (*Mickenautsch et al., 2009*) (*Mandari, Frencken, & van't Hof, 2003*) (*Forsten, 1994*) (*Hicks, Garcia-Godoy, Donly, & Flaitz, 2003*). GIC restorations have also been shown to be antibacterial and decrease biofilm acidogenicity, supposedly from the fluoride release (*Hengtrakool, Pearson, & Wilson, 2006*). However, chemical changes not only occur at the surface of GIC, but also at the tooth-restorative interphase. The transfer of ions between glass ionomer and the tooth (*H. C. Ngo, Mount, Mc Intyre, Tuisuva, & Von Doussa, 2006*) is a well-known part of the chemical bond to tooth mineral (*Yoshida et al., 2000*), forming the "chemically fused" interface or zone (*H. C. Ngo, Mount, Mc Intyre, Tuisuva, & Von Doussa, 2006*) (*Sennou, Lebugle, & Grégoire, 1999*) (*H. Ngo, Ruben, et al., 1997*). Ngo demonstrated this bond to the tooth is stronger than the material itself as demonstrated by cohesive fracture of the material when stressed (*H. Ngo, Ruben, et al., 1997*). This may explain the results of a randomized clinical trial showing GIC sealants had caries protective effects even after they are lost (*Antonson et al., 2012*). Studies reported continued permeability between tooth and clinically set glass ionomer. One study by Yiu demonstrated that water can diffuse from dentin across the chemically fused zone and into the glass ionomer itself (*Yiu et al., 2004*). If water can freely diffuse into and out of glass ionomer, it is speculated that this "semipermeable" characteristic of this unique material can be leveraged to enhance of glass ionomer restorations as in the case of placing a GIC sealant on a newly erupted tooth. Other studies by Ngo have shown that the ion exchange and fluoride release of GIC at the tooth-GIC interphase causes a remineralized chemically fused zone known as "internal remineralization". A remineralized marginal seal that is acid protected is now created (*H. C. Ngo, Mount, Mc Intyre, Tuisuva, & Von Doussa, 2006*). A randomized clinical trial using glass ionomer compared to resin sealants concluded that the caries protective effects (internal remineralization) of GIC continued to protect the teeth of children even after the GIC sealant has been lost. The resin-based sealants had no such protection (*Mickenautsch & Yengopal, 2016*) (*Antonson et al., 2012*).

Tooth Preserving Caries Removal

The ability of GIC to provide an acid resistant marginal seal and internal remineralization makes it an ideal dental material for advanced caries lesions. The goal of treating these lesions is to preserve tooth structure and pulp vitality. By definition, the atraumatic restorative technique (ART) uses hand instrumentation to partially remove debris before placing a restoration. GIC has been used successfully for the ART technique in remote areas to arrest gross decay (*Mertz-Fairhurst, Curtis, Ergle, Rueggeberg, & Adair, 1998*). ART employs selective or partial caries removal using GIC as a restorative material over any remaining deeper infected tooth structure. This technique promotes protection from mechanical pulp exposure and preserves the health of an asymptomatic vital pulp (*Thompson, Craig, Curro, Green, & Ship, 2008*) (*Ricketts, Kidd, Innes,*

& Clarkson, 2009) (*Schwendicke et al., 2016*). *By establishing a seal at the margins, this technique prevents nutrients from reaching remaining bacteria and has been demonstrate to halt acid production and demineralization* (*Thompson, Craig, Curro, Green, & Ship, 2008*) (*Ricketts, Kidd, Innes, & Clarkson, 2009*). *The result is lesion arrest* (*Thompson, Craig, Curro, Green, & Ship, 2008*) (*Ricketts, Kidd, Innes, & Clarkson, 2009*). In a study by Ngo, where GIC was placed in direct contact with affected dentin, extensive migration of strontium and fluoride from the GIC was found in deeper areas of carious dentin and reached depths over 1.5mm (*Ngo, Mount, Mc Intyre, Tuisuva, & Von Doussa, 2006*).

Surface Sealant

Glass ionomer can be used as a therapeutic coating or "surface sealant" which protects mechanically and chemically with long-term fluoride delivery and with fluoride ion (F-) "recharging capability". This refers to the fact that the F- can be replenished by use of fluoride-containing products. It is clinically useful when patients are unable to render effective oral hygiene. It is ideal for root protection in the elderly as well as coronal protection on a newly erupted tooth in a child (*Forsten, 1994*). Glass ionomer has successfully sealed occlusal pits and fissures (*Mount, 2002*) (*Mount & Hume, 2005*). Unlike resin-based materials, glass ionomer will chemically bond equally well to both prismatic and aprismatic enamel (*Yoshida et al., 2000*). Prior to placement of the GIC, pits and fissures should still be clean and free from plaque or debris. It is an excellent base material for large or deep restorations (*Forsten, 1994*). GIC has been used in the "open sandwich" technique with mixed results. In this technique, GIC is placed in the approximal box below the contact and composite is placed occlusal to the contact. With the new stronger GIC materials available today, specifically marketed for class II restorations, the sandwich technique is being replaced with simply bulk filling with GIC. The improved newer material has contributed to the demise of the open sandwich technique. It is more likely that a class II restorative will be bulk filled with GIC.

Glass Ionomer Characteristics

In the chemical treatment of caries disease, we recognize that GICs are anti-cariogenic in nature primarily due to fluoride release. Studies that evaluate acidogenicity of Streptococcus mutans biofilm and the effects of GIC suggest an anti-cariogenic biofilm is correlated with GIC's fluoride release (*Chau, Pandit, Cai, Lee, & Jeon, 2015*).

GIC Application Techniques for Improving Clinical Outcomes

Having the right material but handling it incorrectly can lead to premature failure. In order for the greatest chance of success, GICs need a *clean* tooth surface with which to chemically react. The water component of the glass ionomer needs to be kept in mind at all times. The biofilm or pellicle of the tooth surface must be cleaned with pumice to allow optimal chemical interaction. The dentin surface should remain moist upon placement of the GIC after proper tooth conditioning with polyacrylic acid and rinsing. Over manipulation of the GIC or air drying the surface can cause breakdown in the material resulting in cracking of the GIC surface. It is imperative to protect the restoration surface during setting to prevent potential restoration failure. Lastly, it is imperative to use profuse amounts of water during the contouring and finishing phase of the GIC restoration to prevent desiccation.

Silver Modified Atraumatic Restorative Treatment (SMART) Restorations

The evolution from G. V. Black's "extension for prevention" philosophy to minimally invasive dentistry is becoming more popular with patients and clinicians. Newer dental materials and evidenced-based studies support the importance of conserving tooth structure. The focus must be conservation of healthy tooth structure and the repair and remineralization of teeth. Adherence to this new evidence-based philosophy, surgical removal of tooth structure can often be avoided altogether.

SDF has an antibacterial effect upon contact with bacteria. The obvious question after separately considering the benefits of SDF, conventional GIC, and selective caries removal used by themselves would be "How can they be combined into one clinical procedure?" The Silver Modified Atraumatic Restorative Treatment (SMART) combines the chemical benefits of SDF and GIC and utilizes the concepts of partial caries removal to seal out external bacteria and their nutritional sources, preserve and remineralize tooth structure. Therefore, if there is an immediate need to fill the cavitation with a restoration, the combination of compatible philosophies should yield a symbiotic result; an arrested, acid protected, remineralized lesion with a sealed restoration.

The Anti-cariogenic Effects of GIC

Along with ease of placement makes the restoration efficient and effective. By using chemical set GIC, the adverse darkening of light cured-resin-based materials is averted. There is no evidence, at this time, to indicate that there are any negative interactions with SDF and GIC. The SMART preparation design requires a clean 2mm margin at the cavosurface (the margins of the cavity preparation) to allow the glass ionomer sufficient area to seal out external contamination and facilitate remineralization. This is a one-step restorative procedure combining SDF, selective caries removal and GIC placement. The SMART restoration may be considered an interim treatment or, if properly polished and protected, the final restoration. The advantage of the SMART restoration is that it halts the demineralization process at the tooth level allowing time for caries risk assessment and behavioral changes to positively impact caries disease progression. Understanding the science and advantageous properties of SMART is important to not only repair the tooth, but also treat the disease. Patients should be aware of the procedure and informed of the purpose of SMART should they be seen by another clinician in the future who may not be familiar with the technique.

Concerns When GIC and SDF are Used Together

The main concern is the possible darkening of demineralized tooth structure or the restoration over time. Proper patient informed consent should include address of the darkening potential. Clinical observations suggest that for best esthetics results the free silver must be allowed to be cleared (diffuse away) before placing the final restoration based on the clinician's discretion. When the tooth is properly prepared; GIC mixed and placed to manufacture specifications; finished and properly surface protected as described previously; there does not appear to be any detrimental concerns for using the combination of GIC and SDF, providing a curing light is not used. Depending on the GIC selected, and, if the GIC and SDF are placed at the same appointment, some darkening of the GIC is possible.

Communication and Consent

The concepts of caries risk management by combining SDF with selective caries removal and glass ionomer cement restorations represent unique treatment options that could be communicated to patients as a viable treatment option under certain circumstances. At this time, not all clinicians or patients are aware of this option. As such, along with the benefits, proper patient education and informed consent should be obtained including the potential risks including discoloration. After caries lesion arrest, the decision to restore or not can be considered once the caries disease process is under control.

Necessary Conditions for a SMART Restoration:

- A vital, asymptomatic active carious lesion (cavitated or non-cavitated).
- Patient cooperation level: able to tolerate some air and water spray.
- Able to open their mouth for a few minutes at a time.
- Capacity to thoroughly understand the proposed procedure and give adequate consent.

Contraindications to SMART

Silver allergy is an *extremely rare* condition, but should it be verified, is a strict contraindication. Clinically, any tooth which has irreversible pulpitis, necrotic or irreversible symptoms, are also contraindicated for SMART restorations. Sound clinical judgement should be exercised in any case selection

Selecting the Right GIC for the Right Clinical Situation

There are many brands of glass ionomer cements including some that market themselves using terminology consistent with glass ionomers but are not true glass ionomers as defined earlier in this chapter. Resin modified glass ionomers allow for a rapid set with a curing light, however the resin content is believed to delay the acid-base reaction of the glass ionomer for almost seven days compared to 24 hours for conventional GIC.[50] The authors recognize that personal preference in handling properties and esthetics is always a consideration. There does not seem to be a uniform method of comparisons found in literature for all "glass ionomer products" nor is there consistent well-defined terminology used in the product information descriptions. Many factors including unit dose versus hand mixing of the material can change the properties vastly. In selecting a GIC, the clinician should consider the filler particle, viscosity, and esthetic properties best suited for the individual patient. Factors such as lesion location, size of restoration, isolation concerns, and patient cooperation also influence GIC selection. A patient should be properly informed of risks, benefits, and alternatives for SMART with respect to their caries risk levels in order to make a proper informed consent. given that the SMART procedure is new and constantly evolving, the following step-by-step guideline is given as an example only and will vary depending on a particular clinical situation.

Step-by-Step Instructions for SMART Application

1. Place SDF
2. Remove biofilm and pellicle with pumice

or defocused air abrasion of the surrounding area of the lesion to be treated .

3. Clean the perimeter of the restoration.

4. Condition the lesion and surrounding area with 20% polyacrylic acid by scrubbing for 10 seconds.

5. Rinse with water for 10 seconds.

6. Place and secure a matrix if needed.

7. If any contamination exists, rinse again and blot dry with cotton leaving a moist “glossy” surface.

8. Mix the GIC according to manufacturer’s guidelines and apply immediately. Use care to prevent voids in material placement.

9. Quickly shape and remove excess but do not manipulate the GIC during the initial crosslinking phase according to manufacturer’s guidelines to avoid cracking of the GIC material.

10. When crosslinking is initiated, the wet glossy surface of the GIC will start to look “frosty”. Then seal the restoration according to manufacturer’s guideline An alternative to a surface sealant is to use coco butter to cover the restoration or wet with saliva or water.

11. Do not disturb for 2.5 minutes according to manufacturer’s guidelines .

12. Once set, it is possible to place occlusal anatomy

13. Check occlusion.

14. Caution to avoid chewing on the restoration surface for at least twenty-fours.

SMART Restorations

The following two photos are examples from Dr. John Frachella, of primary teeth with large caries lesions which had been treated with SDF followed by GIC. These teeth then survived until exfoliation with no symptoms. Please notice that the normally white GIC material had turned gray due to the presence of silver ions.

Example of SMART Sealants

GIC sealant placement after caries arrest from SDF application post SDF application – provided by Dr. Steve Duffin.

Please watch this instructive video by Dr. Doug Young about GIC strength

- http://www.mmclibrary.com/GIC_testing.html

References

Albers, H. F. (2002). Tooth colored restoratives principles and techniques. Hamilton [U.A.] Decker.

Ames, W. B. (1892). A new oxyphosphate for crown seating. Dental Cosmos, 34, 392–393.

Antonson, S. A., Antonson, D. E., Brener, S., Crutchfield, J., Larumbe, J., Michaud, C., … Ocanto, R. (2012). Twenty-four month clinical evaluation of fissure sealants on partially erupted permanent first molars. The Journal of the American Dental Association, 143(2), 115–122. https://doi.org/10.14219/jada.archive.2012.0121

Chau, N. P. T., Pandit, S., Cai, J.-N., Lee, M.-H., & Jeon, J.-G. (2015). Relationship between fluoride release rate and anti-cariogenic biofilm activity of glass ionomer cements. Dental Materials, 31(4), e100–e108. https://doi.org/10.1016/j.dental.2014.12.016

Christensen, G. J. (2000). The need for caries-preventive restorative materials. The Journal of the American Dental Association, 131(9), 1347–1349. https://doi.org/10.14219/jada.archive.2000.0391

Cranfield, M., Kuhn, A. T., & Winter, G. B. (1982). Factors relating to the rate of fluoride-ion release from glass-ionomer cement. Journal of Dentistry, 10(4), 333–341. https://doi.org/10.1016/0300-5712(82)90028-8

Featherstone, J. (2006). Caries Prevention and Reversal Based on the Caries Balance. Pediatric Dentistry, 28(2), 128–132.

Fleck, D. J. (1902). The chemistry of oxyphosphates. Dent Items Int, 24, 906.

Forsten, L. (1991). Fluoride release and uptake by glass ionomers. European Journal of Oral Sciences, 99(3), 241–245. https://doi.org/10.1111/j.1600-0722.1991.tb01891.x

Forsten, L. (1994). Flouride Release of Glass Ionomers. Journal of Esthetic and Restorative Dentistry, 6(5), 216–222. https://doi.org/10.1111/j.1708-8240.1994.tb00862.x

Gorton, J., & Featherstone, J. D. B. (2003). In vivo inhibition of demineralization around orthodontic brackets. American Journal of Orthodontics and Dentofacial Orthopedics, 123(1), 10–14. https://doi.org/10.1067/mod.2003.47

Hengtrakool, C., Pearson, G. J., & Wilson, M. (2006). Interaction between GIC and S. sanguis biofilms: Antibacterial properties and changes of surface hardness. Journal of Dentistry, 34(8), 588–597. https://doi.org/10.1016/j.jdent.2005.02.011

Hicks, J., Garcia-Godoy, F., Donly, K., & Flaitz, C. (2003). Fluoride-releasing restorative materials and secondary caries. Journal of California Dental Association, 31(3), 229–245.

Hurlbutt, M., & Young, D. A. (2014). A Best Practices Approach to Caries Management. Journal of Evidence Based Dental Practice, 14, 77–86. https://doi.org/10.1016/j.jebdp.2014.03.006

Jenson, L., Budenz, A. W., Featherston, J. D., Ramos-Gomez, F. J., Spolsky, V. W., & Young, D. A. (2007). Clinical protocols for caries management by risk assessment. Journal of California Dental Association, 35(10), 714–723.

Kemp-Scholte, C. M., & Davidson, C. L. (1988). Marginal Sealing of Curing Contraction Gaps in Class V Composite Resin Restorations. Journal of Dental Research, 67(5), 841–845. https://doi.org/10.1177/00220345880670050901

Leach, S. A., & Puttnam, N. A. (1962). Infrared Studies of the Interaction of Weak Acid Anions with Hydroxyapatite. Journal of Dental Research, 41(3), 716–716. https://doi.org/10.1177/00220345620410032901

Mandari, G. J., Frencken, J. E., & van't Hof, M. A. (2003). Six-Year Success Rates of Occlusal Amalgam and Glass-Ionomer Restorations Placed Using Three Minimal Intervention Approaches. Caries Research, 37(4), 246–253. https://doi.org/10.1159/000070866

Mertz-Fairhurst, E. J., Curtis, J. W., Ergle, J. W., Rueggeberg, F. A., & Adair, S. M. (1998c). Ultraconservative and cariostatic sealed restorations: results at year 10. The Journal of the American Dental Association, 129(1), 55–66. https://doi.org/10.14219/jada.archive.1998.0022

Mickenautsch, S., & Yengopal, V. (2016). Caries-Preventive Effect of High-Viscosity Glass Ionomer and Resin-Based Fissure Sealants on Permanent Teeth: A Systematic Review of Clinical Trials. PLOS ONE, 11(1), e0146512. https://doi.org/10.1371/journal.pone.0146512

Mickenautsch, Steffen & Yengopal, V & Leal, Soraya & Oliveira, Luciana & Bezerra, Ana & Bönecker, Marcelo. (2009). Absence of carious lesions at margins of glass-ionomer and amalgam restorations: A meta-analysis. European journal of paediatric dentistry : official journal of European Academy of Paediatric Dentistry. 10. 41-6.

Mjör, I. A., & Gordan, V. V. (1999). A review of atraumatic restorative treatment (ART). International Dental Journal, 49(3), 127–131. https://doi.org/10.1002/j.1875-595x.1999.tb00896.x*

Mount, G. J. (2002). An atlas of glass-ionomer cements : a clinician's guide. London: Martin Dunitz.

Mount, G. J., & Hume, W. R. (2005). Preservation and restoration of tooth structure. Sandgate, Qld.: Knowledge Books And Software.

Mustafa, N. B., Chan, D. C. N., Titus, H. W., & Yang, Z. (2016). Fluoride release from restorative materials after exposure to NaF. Journal of Dental Research, 75(Special), 382.

Ngo, H. C., Mount, G., Mc Intyre, J., Tuisuva, J., & Von Doussa, R. J. (2006). Chemical exchange between glass-ionomer restorations and residual carious dentine in permanent molars: An in vivo study. Journal of Dentistry, 34(8), 608–613. https://doi.org/10.1016/j.jdent.2005.12.012

Ngo, H., Mount, G. J., & Peters, M. C. (1997). A study of glass-ionomer cement and its interface with enamel and dentin using a low-temperature, high-resolution scanning electron microscopic technique. Quintessence International, 28(1), 63–69.

Ngo, H., Ruben, J., Arends, J., White, D., Mount, G. J., Peters, M. C. R. B., … Pfarrer, A. (1997). Electron Probe Microanalysis and Transverse Microradiography Studies of Artificial Lesions in Enamel and Dentin: A Comparative Study. Advances in Dental Research, 11(4), 426–432. https://doi.org/10.1177/08959374970110040801

Nicholson, J. W. (1998). Chemistry of glass-ionomer cements: a review. Biomaterials, 19(6), 485–494. https://doi.org/10.1016/s0142-9612(97)00128-2

Okada, K., Tosaki, S., Hirota, K., & Hume, W. . (2001). Surface hardness change of restorative filling materials stored in saliva. Dental Materials, 17(1), 34–39. https://doi.org/10.1016/s0109-5641(00)00053-1

Ramos-Gomez, F., & Ng, M. W. (2011). Into the future: keeping healthy teeth caries free: pediatric CAMBRA protocols. Journal of the California Dental Association, 39(10), 723–733.

Ricketts, D., Kidd, E., Innes, N., & Clarkson, J. (2009). Complete or ultraconservative removal of decayed tissue in unfilled teeth. Australian Dental Journal, 54(3), 274–276. https://doi.org/10.1111/j.1834-7819.2009.01133.x

Schwendicke, F., Frencken, J. E., Bjørndal, L., Maltz, M., Manton, D. J., Ricketts, D., … Innes, N. P. T. (2016). Managing Carious Lesions. Advances in Dental Research, 28(2), 58–67. https://doi.org/10.1177/0022034516639271

Sennou, H. E., Lebugle, A. A., & Grégoire, G. L. (1999). X-ray photoelectron spectroscopy study of the dentin–glass ionomer cement interface. Dental Materials, 15(4), 229–237. https://doi.org/10.1016/s0109-5641(99)00036-6

Smales, Roger & Ngo, Hien & Yip, Kevin & Yu, Chang. (2005). Clinical effects of glass ionomer restorations on residual carious dentin in primary molars. American journal of dentistry. 18. 188-93.

Smith, D. C. (1967). A new dental cement. British Dental Journal, 123(11), 540–541.

Smith, D. C. (1968). A new dental cement. British Dental Journal, 124(9), 381–384.

Surveillance for Dental Caries, Dental Sealants, Tooth Retention, Edentulism, and Enamel Fluorosis --- United States, 1988--1994 and 1999--2002. (2019). From http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5403a1.htm

Thompson, V. T., Craig, R. G., Curro, F. A., Green, W. S., & Ship, J. A. (2008). Treatment of deep carious lesions by complete excavation or partial removal. The Journal of the American Dental Association, 139(6), 705–712. https://doi.org/10.14219/jada.archive.2008.0252

Van Duinen, R. N., Davidson, C. L., De Gee, A. J., & Feilzer, A. J. (2004). In situ transformation of glass-ionomer into an enamel-like material. American Journal of Dentistry, 17(4), 223–227.

Wall, F. T., & Drenan, J. W. (1951). Gelation of polyacrylic acid by divalent cations. Journal of Polymer Science, 7(1), 83–88. https://doi.org/10.1002/pol.1951.120070107

Wan, A. C. A., Yap, A. U. J., & Hastings, G. W. (1999). Acid–base complex reactions in resin-modified and conventional glass ionomer cements. Journal of Biomedical Materials Research, 48(5), 700. https://doi.org/10.1002/(sici)1097-4636(1999)48:5<700::aid-jbm15>3.3.co;2-t

Wilson, A. D., & Kent, B. E. (1972). A new translucent cement for dentistry. The glass ionomer cement. British Dental Journal, 132(4), 133–135. https://doi.org/10.1038/sj.bdj.4802810

Wu, D. I., Velamakanni, S., Denisson, J., Yaman, P., Boynton, J. R., & Papagerakis, P. (2016). Effect of Silver Diamine Fluoride (SDF) Application on Microtensile Bonding Strength of Dentin in Primary Teeth. Pediatric Dentistry, 38(2), 148-153(6).

Yiu, C. K. ., Tay, F. ., King, N. ., Pashley, D. ., Carvalho, R. ., & Carrilho, M. R. . (2004). Interaction of resin-modified glass-ionomer cements with moist dentine. Journal of Dentistry, 32(7), 521–530. https://doi.org/10.1016/j.jdent.2004.04.005

Yoshida, Y., Van Meerbeek, B., Nakayama, Y., Snauwaert, J., Hellemans, L., Lambrechts, P., … Wakasa, K. (2000). Evidence of Chemical Bonding at Biomaterial-Hard Tissue Interfaces. Journal of Dental Research, 79(2), 709–714. https://doi.org/10.1177/00220345000790020301

Young, D. (2006). The use of glass ionomers as a chemical treatment for caries. Practical Procedures & Aesthetic Dentistry, 18(4), 248–250.

Young, D. A., & Featherstone, J. D. B. (2013). Caries management by risk assessment. Community Dentistry and Oral Epidemiology, 41(1), e53–e63. https://doi.org/10.1111/cdoe.12031

Young, D. A., Featherstone, J. D. B., Roth, J. R., Anderson, M., Auti-Gold, J., Christensen, G. J., … Wolff, M. (2007). Caries management by risk assessment: implementation guidelines. Journal of the California Dental Association., 35(11), 799–805.

Young, D. A., Nový, B. B., Zeller, G. G., Hale, R., Hart, T. C., Truelove, E. L., Beltran-Aguilar, E. (2015). The American Dental Association Caries Classification System for Clinical Practice. The Journal of the American Dental Association, 146(2), 79–86. https://doi.org/10.1016/j.adaj.2014.11.018

SMART Restorations in the Primary and Permanent Dentition

(Dr. Steve Duffin, DDS)

Early demineralization in the caries process may often be reversed and the lesion become remineralized under the right conditions. Once a lesion advances to the stage of cavitation, it may become necessary to place some kind of restoration in order to retain function and-or improve esthetics. There is a distinction that should be kept in mind with respect to the primary and the permanent dentition when considering this intervention. Primary teeth serve for a maximum of 10-12 years before exfoliation. Permanent teeth need to function for up to 100 years. The technique of arresting caries with silver ion products and then atraumatically restoring the tooth with glass ionomer cement products is explored rather extensively in this manuscript. This approach is well suited for young children who may not be fully cooperative and for the treatment of primary teeth. When considering restorations in permanent teeth, I suggest that a longer perspective must be kept in mind. In years past, a well-done permanent restoration was considered the standard of care approach for treatment of a caries lesion. We now know that restorations often fail due to recurrent decay and new lesions appear in the same patient. Placing restorations *does not* treat the cause of cavities, but it *is a symptomatic intervention*. The Medical Management of Caries philosophy "MMC", reaches beyond this short-term perspective and takes into consideration the full spectrum of conditions that lead to health or disease states. This philosophy encourages the clinician to consider *first* treating a caries lesion with the *appropriate antimicrobial agent* in order to eliminate the *cause* of infection *prior* to proceeding with restorations. Silver ion products have been shown to be our most effective tool to achieve this objective. **Consider the following:**

> *"If the house is on fire, call the fire department, don't call the carpenters" -Dr. Robert Barkley, Father of Preventive Dentistry*

And…

> *"The dominant practice of placing restorations as a means of controlling caries has not succeeded. The restore and repair paradigm has failed." -Dr. Mike Shirtcliff, CEO of Advantage Dental in Redmond, OR*

Epidemiology of Dental Caries

(Dr. Amal Noureldin, BDS, MSD, MS, PhD)

Educational Objectives

The Learner will be able to explore and recognize dynamics of a disease within populations, recognize the impact of finding and implementing novel anticaries interventions

Keywords

Prevalence: The percentage of individuals in a population with the condition

Incidence: The number of new cases that appears in a population over time

Severity: Severity represents the degree to which a disease impacts the normal functions of an individual. For example: a child in Ghana with one asymptomatic caries lesion into dentin may be classified as having caries. Another child in Bolivia with caries lesions in sixteen of twenty teeth, five with pulpal involvement and pain, also has caries but clearly this is a very different clinical situation.

Intervention: A treatment meant to impact either the incidence, prevalence or the severity of a disease manifestation.

Outcome: The clinical result of treatment

Assessment: The field of epidemiology possesses many sophisticated mathematical tools for evaluating the changing dynamics of disease and the effects of various interventions.

It is not the intent of the authors to fully explore the important field of epidemiology but only to provide an outline of its main functions as a tool for analyzing the presence and dynamics of a disease within populations. This is particularly true for the condition of tooth decay, and how the introduction of novel anticaries interventions such as SDF may impact the disease at the population level. At the end of this chapter, four excellent reference books will be mentioned that may serve the conscientious student in additional investigation of this topic.

Importance of Epidemiology

It has been suggested that the field of epidemiology was born from the work of English physician John Snow who published a fascinating proposal in 1849 suggesting that cholera may be transmitted to susceptible individuals through contaminated water systems. He came to this conclusion by conducting a detailed mathematical analysis of the appearance of new cases of cholera in the SOHO section of London. Snow was widely criticized by contemporaries until the evidence of his discovery became overwhelming and an intervention with chlorine water treatment proved effective in stopping the epidemic (*Vinten-Johansen & Al, 2003*).

The recent definition of epidemiology in 1988 was “the study of the distribution and determinants of health-related states or events in specified populations, application of this study to the control of health problems” (*Seidl, Last, & International Epidemiological Association, 1988*). Epidemiology's broad goal is to improve the population’s health. Hence, it seeks to discover the causes of the disease to deepen our understanding. Current epidemiology expands

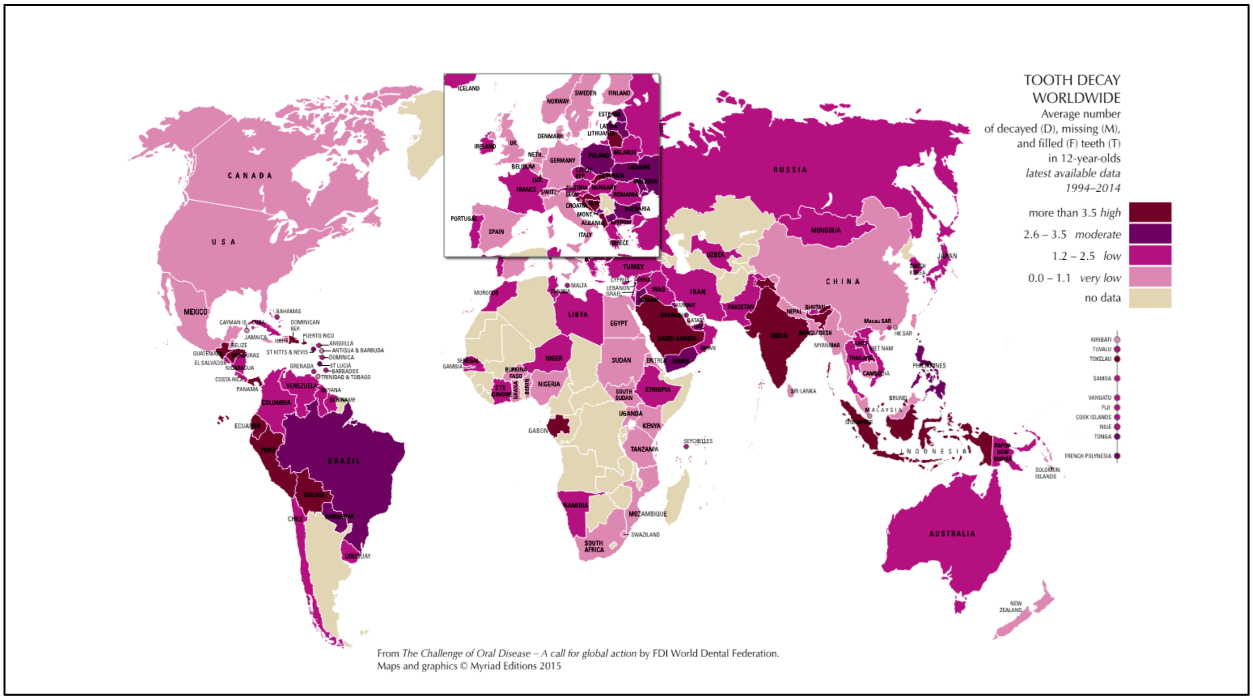


Figure 1: Tooth decay worldwide.

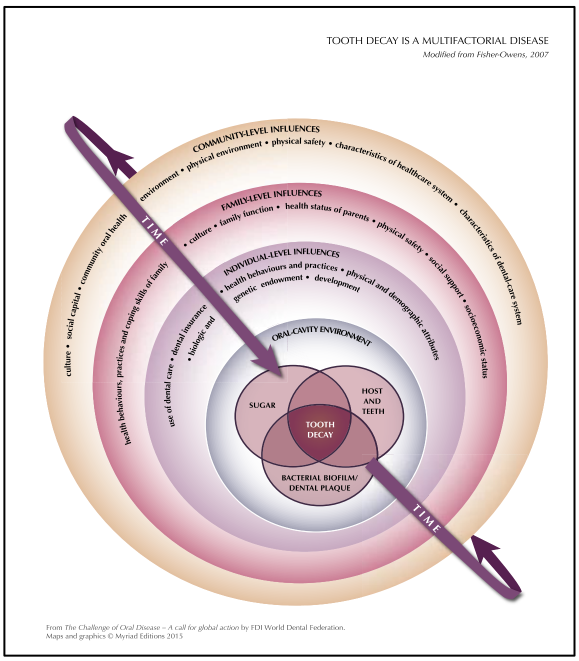


Figure 2: Tooth decay causal factors.

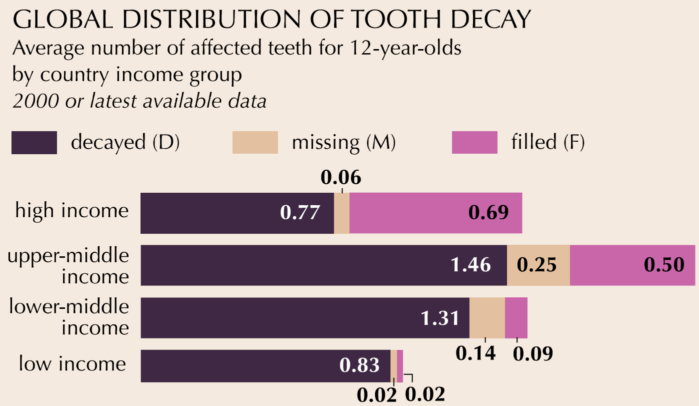
across all health fields. The focus is on identifying the causes, quantifying the burden of the disease, measuring the therapeutic effectiveness of different treatment modalities and monitoring activities. It is crucial that health professionals gather epidemiological data to contribute to a more informed team of health providers' concerning treatments, assistance and health policies (*Edelstein, 2006*).

Epidemiology and the Disease of Dental Caries

In the field of epidemiology, the patient is the community of individuals who may be susceptible to some medical condition. Caries is the most common communicable disease of mankind, effecting many billions of individuals worldwide to various degrees. As mentioned earlier, the first focus of epidemiology is to identify the causes of the disease.

Upstream Causes of Dental Caries Disease

Unlike cholera and smallpox, caries is not a single pathogen disease, but rather the result of the effects of a large number of pathogenic oral bacteria working together in a biofilm to produce



The DMFT Index

The DMFT index is generally used to report tooth decay in epidemiological studies. It records the number of decayed (D), missing (M) and filled (F) teeth (T). While DMFT is not the only measure and has limitations, the oral health status of populations is often summarized as a DMFT score (usually of 12-year-olds). A DMFT score of 1.0 means that 1 of the 32 adult teeth is either decayed, missing or filled. Scores for individuals are full numbers, for populations they can have decimal values.

From *The Challenge of Oral Disease – A call for global action* by FDI World Dental Federation.

Figure 3: Global distributrion of tooth decay based on income.

acid and demineralize the teeth. This collection of bacterial species may be as unique to any given individual as is their fingerprint.

There are major landmarks through history that lead to discovery of all the contributing causal factors of caries (Fig.2). The decline of caries during World War II was documented around 1950 in Toverud's ecological studies. During post-war years and following the drastic changes of the food supply, a rise in caries prevalence was documented (*Toverud, 1949*) (*Toverud, 1957*).

The 5-year longitudinal Vipeholm study *(Gustafsson et al., 1953*) among groups of institutionalized mentally disabled people supported the observation that frequency of sugar consumption and the stickiness of the sugar-containing food were key parameters and had a direct relation to caries development. In the 1960s, dental caries was largely considered a dietary disease with a potential hereditary component (*Tanzer, 1995*). The scientist Keyes animal work on genetic heritability, targeting the individual 'susceptibility' to caries development (*Keyes, 1960*), changed the focus to dental plaque.

From this point on, caries causation was biologically based on the Keyes Triad: Diet/sugar, plaque/bacteria, and host/tooth. Later, the causation of caries was expanded to include more factors such as: saliva, salivary flow, buffer capacity, sugar clearance rates, and a few socio-behavioral elements (*Keyes, 1962*). The addition of a time factor to the model was to indicate the ecological shift in the process of de- and remineralization. However, to understand the occurrence of caries in individuals and in populations, we cannot be limited to this strictly biological causation of the disease (*Kingman, 2005*) (*Athanassouli et al., 1994*).

These socio-behavioral factors were not considered genuine causes of caries because they were not among the biological factors. It is the social determinants of diet and oral hygiene practices which also contribute to the presence and severity of caries in the individual and as seen in populations. Caries has long been linked to socioeconomic status as a major risk factor. Higher levels of tooth decay are seen in populations with lower economic resources. Whether this is due to a lack of access to professional dental care, dietary choices, microbial composition or other factors remain to be fully worked out.

The Burden and Challenge of the Disease

It is been thoroughly documented in the dental literature, that caries severity is declining in most countries around the world. In particular: the highly industrialized countries, (*Carvalho, D'Hoore, & Van Nieuwenhuysen, 2004*) (*de Liefde, 1998*) (*Haugejorden & Magne Birkeland, 2006*) (*Marthaler, 2004*) (*Poulsen & Malling Pedersen, 2002*) (*Stecksén-Blicks, Sunnegårdh, & Borssén, 2004*) (*Beltrán-Aguilar, Estupiñán-Day, & Báez, 1999*), Latin American and Caribbean countries, (*Carvalho, Figueiredo, Vieira, & Mestrinho, 2008*) (*Cleaton-Jones, Fatti, & Bönecker, 2006*) (*Aleksejuniene, Holst, & Balciuniene, 2004*), Eastern European countries (*Künzel, 1996*) (*Szoke & Petersen, 2000*) (*Cleaton-Jones & Fatti, 1998*), and African countries (*Cleaton-Jones & Fatti, 2009*) (*Eriksen, 1998)*.

Most of these studies that reported the decline in caries prevalence have been carried out among children and adolescents. Some researchers were concerned that the reported caries decline among children and adolescents may merely represent a delay in the development of caries (*Schuller & Holst, 1998*) (*Vilstrup, Christensen, Hede, & Kristensen, 2010*) (*Hugoson & Koch, 2008*). On the other hand, it was reported among the older age groups a trend of increasing tooth retention and reduced edentulism (*Vilstrup, Christensen, Hede, & Kristensen, 2010*) (*Hugoson & Koch, 2008*) (*Kassebaum et al., 2015*) which leads to higher DMFT among the 60, 70, and 80-year-olds (Hugoson, Koch, Helkimo, & Lundin, 2007). A very interesting research paper consolidated all epidemiologic data about untreated caries and subsequently generated internally consistent data on prevalence and incidence estimates for all countries, age groups, and both sexes for 1990 and 2010 (*Cleaton-Jones, Fatti, & Bönecker, 2006*). The prevalence and incidence between regions and countries varied considerably. The global age-standardized prevalence and incidence of untreated caries remained static between 1990 and 2010. It was very clear from the evidence that the burden of untreated caries is shifting from children to adults, with 3 peaks in prevalence at ages 6, 25, and 70 (*Baelum et al., 2003*). Based on these epidemiological findings and data, policy makers need to be aware of a predictable increasing burden of untreated caries due to population growth and the significant decrease in the prevalence of total tooth loss throughout the world from 1990 to 2010.

The caries experience varies within a population. Based on the FDI report of 2015, caries levels were considered generally high, when the prevalence of dmf/DMF>0 is typically found to be close to 100%. The individual dmf/DMF counts are distributed almost symmetrically around their population mean value and the associated standard deviation is typically much smaller than the mean value (*Machiulskiene, Nyvad, & Baelum, 1998*) (*Machiulskiene, Richards, Nyvad, & Baelum, 2002*) (*Watt, 2007*). Figure 3 illustrates the data from a population that had relatively high caries levels two decades ago.

Epidemiology and Public Caries Control Methods

It is a global goal to develop disease-prevention strategies based on broad social and environmental determinants of health; adapting upstream rather than downstream strategies. Prevention and control of caries can have several entry points both at the population and the individual levels. Population and policy level interventions are highly cost-effective and it is recommended to apply multilevel, combined approaches (*Holst, 2008*).

Public Health Approaches to Address Caries

Achieving and maintaining good population health, will contribute to a nation's well-being. governments may provide an environment with living conditions conducive to health. Governments have public policy options to influence exposure to caries risk factors and influence consumption as well as use of certain unhealthy products (*Agbaje et al., 2012*). There are many examples of successful legislation and regulations that use policy tools and templates developed by the WHO and other organizations which result in significant positive health benefits (*Watt, 2007*) (*Holst, 2008*) (*Agbaje et al., 2012*) (*Centers for Disease Control and Prevention (CDC), 1999*).

Fluoride Strategies

The use of fluorides has been widely accepted as the most cost-effective and a commonly used way of reducing the burden of caries. Perhaps one of the most famous examples is that of water fluoridation. G. V. Black himself investigated the strange correlation between “Colorado Brown Stain” and reduced caries rates in 1910. Following many decades of investigation, a large highly controlled clinical trial was carried out in 1945 to compare the addition of fluoride to the water supply of Grand Rapids Michigan with Muskegon as a control site. The success of this project has resulted in the optimization of water fluoride levels in many communities throughout the United States. This is an example on the introduction of a specific intervention which had a dramatic population effect on an endemic disease. The science of epidemiology was at the core of every step of this process.

Water fluoridation

Water fluoridation is considered one of the most successful public health interventions of the 20th century to limit the caries epidemic (*Centers for Disease Control and Prevention (CDC), 1999*). The WHO promotes "automatic fluoridation" measures where fluoride exposure is less dependent on compliance (such as fluoridation of water, salt, or milk) (Petersen & Lennon, 2004). From a global perspective, most of the high-income countries use water fluoridation but worldwide only 5% of the world’s population are provided with artificial water fluoridation. No low-income countries and only a few middle-income countries have water fluoridation (*Centers for Disease Control and Prevention (CDC), 1999*) (*Petersen & Lennon, 2004*) (*Center for Medicare & Medicaid Services, 2012*) (*British Fluoridation Society, 2016*). Many countries are faced with arguments against "compulsory mass medication" which deprive the individual of the right to make an informed choice. Taking such ethical consideration into account, several European countries ceased water fluoridation.

Salt and milk fluoridation

Adding fluorides to salt and milk does not present the ethical drawbacks of water fluoridation, since the consumer has the option to purchase fluoridated or non-fluoridated products. Salt fluoridation has its own technical and practical problems as it requires quality control. Only 4% of world’s population has access to these methods.

Fluoridation of milk has been proposed for school programs and is considered a good alternative method to provide fluoride. The evidence for the effectiveness of milk fluoridation remains equivocal. But challenges remain like the need of cold storage as well as widely prevalent lactose intolerance.

Professionally applied fluorides

Professionally applied fluoride vehicles have been used in a number of community or school-based prevention programs. They need to be applied at regular intervals and include fluoride gels, varnishes, foam, and rinses. However, concern has been raised about the significant barriers for using these caries prevention methods in the private and public oral health-care services in the low and middle-income countries. Main barriers are high cost of such professionally administered fluoride agents and the shortages of an appropriately skilled oral health workforce (*Lo, Tenuta, & Fox, 2012*). These approaches are thus largely unrealistic for population-wide caries prevention in such countries.

Policies Strategies

The current international recognition of the growing burden of the caries epidemic has led governments to work towards enacting legislation to control the burden of the disease. Among the most promising and cost-effective approaches for governments is having Innovative legislation to regulate advertising and the marketing of unhealthy foods and products, especially to children.

Policies that address sugar consumption have been implemented considering the detrimental effect of high sugar consumption, particularly of sugar-sweetened beverages since, it has direct effect on incidence and prevalence of caries, diabetes, and obesity. Schools and workplaces are settings that allow for government control and restriction of unhealthy diets high in sugar, salt, and fat and for banning use of tobacco on and around the premises (*Blakely, Wilson, & Kaye-Blake, 2014*) (*Oxman et al., 2009*) (*"Focusing resources on effective school health (FRESH): a FRESH start to improving the quality and equity of education," 2000*) (*Thomas & Gostin, 2013*). Evidence-based school health interventions in particular have a high potential for significant impact on preventable childhood diseases and have been emphasized as effective policy options especially for countries with weak health systems (*Monse et al., 2010*) (*Monse et al., 2013*).

Furthermore, cost-effective preventive approaches, such as universal access to appropriate fluorides for the control of caries, need to be prioritized and strengthened through appropriate national planning.

New Interventions: Silver Diamine Fluoride

The recent FDA approval of SDF represents another opportunity to evaluate the impact of a new fluoride product in the treatment and prevention of dental disease. Much of scientific literature at this time on the efficacy of SDF has come from laboratory studies and case reports. The need and importance of emerging anticaries agents such as SDF is perhaps best understood in terms of the World Health Organization (WHO) Millennium Development Goals for Oral Health (*Hobdell, Petersen, Clarkson, & Johnson, 2003*). The suggested path to achieving this set of goals is the provision of a basic oral health package, consisting of emergency care, prevention, and cost-effective interventions, in that order (*Petersen, 2003*).

The main advantages of SDF are its low-cost, simple, and non-invasive application procedures. Unlike conventional restorative treatments, SDF does not require costly equipment or support infrastructure(*F. Schwendicke et al., 2016*). SDF application can be done by nondental professionals with adequate training. The fact that SDF may be applied by community health workers in settings such as schools and long-term care facilities greatly extends the benefit of the technology into populations globally. It also makes SDF an ideal candidate for public health measures to control caries in the low-income, moderate-income communities, and elderly populations where there is limited or no access to dental services (*Rosenblatt, Stamford, & Niederman, 2009*). 5%–10% of the global health spending is on treating dental caries as estimated by WHO. SDF can fill the void of the need for a cost-effective and potential caries management option. However, there is a need for good-quality data on the effectiveness of oral health interventions and the costs of delivering SDF (*Petersen, 2003*) (*Rosenblatt, Stamford, & Niederman, 2009*) (*Petersen et al., 2005*) (*Robeaglehole, Myriad Editions, & International Dental Federation, 2009*) (*Patel, 2012*).

It is difficult to alter patient habits concerning diet and home care, especially in the Medicaid population, but it is easy to affect anti-microbial intervention via the application of SDF and GIC, both of which have been proven to slow down bacterial destruction.

It is the hope of this writer that over time sufficient data will be accumulated to observe the impact of SDF on a population level and that programs will be developed to extend the benefits of this intervention throughout the world.

SDF even when used by itself can potentially save state Medicaid programs between $15 and $330 per caries-related visit, eventually saving state Medicaid programs millions of dollars. (“EVALUATING POLICY DECISIONS IN HEALTH SYSTEMS, for the Degree Doctor of Philosophy in the H. Milton Stewart School of Industrial and Systems Engineering, Georgia Institute of Technology, August 2017”).

Only 50% of all children with paid-for benefits via Medicaid and private insurance utilize the benefits they already have (Kaiser Family Foundation analysis of Medicaid Current Beneficiary Survey, 2016; National Health and Nutrition Survey 2013-2016). Reasons cited: too expensive, too invasive, and bad previous dental experiences. SMART is non-threatening, non-invasive, and non-traumatic thus SMART is well accepted by phobic dental patients.

References

Agbaje, Jimoh & Lesaffre, Emmanuel & Declerck, Dominique (2012). Assessment of caries experience in epidemiological surveys: a review. Community dental health, 29, 14-9. 10.1922/CDH_2668-Olubanwo06.

Agencies Involved: WHO, UNICEF, UNESCO, World Bank

Aleksejuniene, J., Holst, D., & Balciuniene, I. (2004). Factors influencing the caries decline in Lithuanian adolescents - trends in the period 1993-2001. European Journal of Oral Sciences, 112(1), 3–7. https://doi.org/10.1111/j.0909-8836.2004.00099.x

Athanassouli, I., Mamai-Homata, E., Panagopoulos, H., Koletsi-Kounari, H., & Apostolopoulos, A. (1994). Dental Caries Changes between 1982 and 1991 in Children Aged 6–12 in Athens, Greece. Caries Research, 28(5), 378–382. https://doi.org/10.1159/000262005

Baelum, V., Machiulskiene, V., Nyvad, B., Richards, A., & Vaeth, M. (2003). Application of survival analysis to carious lesion transitions in intervention trials. Community Dentistry and Oral Epidemiology, 31(4), 252–260. https://doi.org/10.1034/j.1600-0528.2003.00045.x

Beltrán-Aguilar, E. D., Estupiñán-Day, S., & Báez, R. (1999). Analysis of prevalence and trends of dental caries in the Americas between the 1970s and 1990s. International Dental Journal, 49(6), 322–329. https://doi.org/10.1111/j.1875-595x.1999.tb00532.x

Blakely, T., Wilson, N., & Kaye-Blake, B. (2014). Taxes on Sugar-Sweetened Beverages to Curb Future Obesity and Diabetes Epidemics. PLoS Medicine, 11(1), e1001583. https://doi.org/10.1371/journal.pmed.1001583

British Fluoridation Society. (2016). The extent of water fluoridation. One in a million - the facts about water fluoridation. Retrieved from bfsweb website: https://www.bfsweb.org/one-in-a-million

Carvalho, J. C., D'Hoore, W., & Van Nieuwenhuysen, J. P. (2004). Caries decline in the primary dentition of Belgian children over 15 years. Community Dentistry and Oral Epidemiology, 32(4), 277–282. https://doi.org/10.1111/j.1600-0528.2004.00166.x

Carvalho, J. C., Figueiredo, M. J., Vieira, E. O., & Mestrinho, H. D. (2008). Caries Trends in Brazilian Non-Privileged Preschool Children in 1996 and 2006. Caries Research, 43(1), 2–9. https://doi.org/10.1159/000181151

Center for Medicare & Medicaid Services. (2012). National Health Expenditures 2012 Highlights. Retrieved from https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/highlights.pdf

Centers for Disease Control and Prevention (CDC). (1999). Ten great public health achievements--United States, 1900-1999. MMWR. Morbidity and Mortality Weekly Report, 48(12), 241–243. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/10220250

Cleaton-Jones, P., & Fatti, P. (1998). Dental caries trends in Africa. Community Dentistry and Oral Epidemiology, 27(5), 316–320. https://doi.org/10.1111/j.1600-0528.1998.tb02027.x

Cleaton-Jones, P., & Fatti, P. (2009). Dental caries in children in South Africa and Swaziland: a systematic review 1919–2007. International Dental Journal, 59(6), 363–368.

Cleaton-Jones, P., Fatti, P., & Bönecker, M. (2006). Dental caries trends in 5- to 6-year-old and 11- to 13-year-old children in three UNICEF designated regions - Sub Saharan Africa, Middle East and North Africa, Latin America and Caribbean: 1970-2004. International Dental Journal, 56(5), 294–300. https://doi.org/10.1111/j.1875-595x.2006.tb00104.x

de Liefde, B. (1998). The decline of caries in New Zealand over the past 40 years. New Zealand Dental Journal, 94(417), 109–113.

Edelstein, B. (2006). The Dental Caries Pandemic and Disparities Problem. BMC Oral Health, 6(S1). https://doi.org/10.1186/1472-6831-6-s1-s2

Eriksen, H. M. (1998). Has caries merely been postponed? Acta Odontologica Scandinavica, 56(3), 173–175. https://doi.org/10.1080/000163598422938

Focusing resources on effective school health (FRESH): a FRESH start to improving the quality and equity of education. (2000). World Education Forum. Senegal.

Gustafsson, B. E., Quensel, C.-E., Lanke, L. S., Lundqvist, C., Grahnén, H., Bonow, B. E., & Krasse, B. (1953). The Effect of Different Levels of Carbohydrate Intake on Caries Activity in 436 Individuals Observed for Five Years. Acta Odontologica Scandinavica, 11(3–4), 232–364. https://doi.org/10.3109/00016355308993925

Haugejorden, O., & Magne Birkeland, J. (2006). Ecological time-trend analysis of caries experience at 12 years of age and caries incidence from age 12 to 18 years: Norway 1985–2004. Acta Odontologica Scandinavica, 64(6), 368–375. https://doi.org/10.1080/00016350600856083

Hobdell, M., Petersen, P. E., Clarkson, J., & Johnson, N. (2003). Global goals for oral health 2020. International Dental Journal, 53(5), 285–288. https://doi.org/10.1111/j.1875-595x.2003.tb00761.x

Holst, D. (2008). Oral health equality during 30years in Norway. Community Dentistry and Oral Epidemiology, 36(4), 326–334. https://doi.org/10.1111/j.1600-0528.2008.00433.x

Hugoson, A., Koch, G., Helkimo, A. N., & Lundin, S.-A. (2007). Caries prevalence and distribution in individuals aged 3–20 years in Jönköping, Sweden, over a 30-year period (1973–2003). International Journal of Paediatric Dentistry, 18, 18–26. https://doi.org/10.1111/j.1365-263x.2007.00874.x

Hugoson, Anders & Koch, Göran (2008). Thirty-year trends in the prevalence and distribution of dental caries in Swedish adults (1973-2003). Swedish dental journal, 32, 57-67.

Kassebaum, N. J., Bernabé, E., Dahiya, M., Bhandari, B., Murray, C. J. L., & Marcenes, W. (2015). Global Burden of Untreated Caries: A Systematic Review and Metaregression. Journal of Dental Research, 94(5), 650–658. https://doi.org/10.1177/0022034515573272

Keyes, P. H. (1960). The infectious and transmissible nature of experimental dental caries. Archives of Oral Biology, 1(4), 304-IN4. https://doi.org/10.1016/0003-9969(60)90091-1

Keyes, P. H. (1962). Recent advances in dental caries research. Bacteriology. Bacteriological findings and biological implications. International Dental Journal, 12, 443–464.

Kingman, A. (2005). Acceptance criteria for clinical caries models. 7th Indiana Conference Clinical Models Workshop: Remin-Demin, Precavitation, Caries., 79–98.

Künzel, W. (1996). Trends in caries experience of 12-year-old children in east European countries. International Journal of Paediatric Dentistry, 6(4), 221–226. https://doi.org/10.1111/j.1365-263x.1996.tb00249.x

Lo, E. C. M., Tenuta, L. M. A., & Fox, C. H. (2012). Use of Professionally Administered Topical Fluorides in Asia. Advances in Dental Research, 24(1), 11–15. https://doi.org/10.1177/0022034511429350

Machiulskiene, V., Nyvad, B., & Baelum, V. (1998). Prevalence and Severity of Dental Caries in 12-Year-Old Children in Kaunas, Lithuania 1995. Caries Research, 32(3), 175–180. https://doi.org/10.1159/000016450

Machiulskiene, V., Richards, A., Nyvad, B., & Baelum, V. (2002). Prospective Study of the Effect of Post-Brushing Rinsing Behavior on Dental Caries. Caries Research, 36(5), 301–307. https://doi.org/10.1159/000065955

Marthaler, T. M. (2004). Changes in Dental Caries 1953–2003. Caries Research, 38(3), 173–181. https://doi.org/10.1159/000077752

Monse, B., Benzian, H., Naliponguit, E., Belizario, V., Schratz, A., & van Palenstein Helderman, W. (2013). The Fit for School health outcome study - a longitudinal survey to assess health impacts of an integrated school health programme in the Philippines. BMC Public Health, 13(1), 256. https://doi.org/10.1186/1471-2458-13-256

Monse, B., Naliponguit, E., Belizario, V., Benzian, H., & van Palenstein Helderman, W. (2010). Essential health care package for children - the "Fit for School" program in the Philippines. International Dental Journal, 60(2), 85–93.

Oxman, A. D., Lavis, J. N., Lewin, S., & Fretheim, A. (2009). SUPPORT Tools for evidence-informed health Policymaking (STP) 10: Taking equity into consideration when assessing the findings of a systematic review. Health research policy and systems, 7, Suppl 1, S10. doi:10.1186/1478-4505-7-S1-S10

Patel, R. (2012). The State of Oral Health in Europe Report Commissioned by the Platform for Better Oral Health in Europe. Retrieved from http://www.oralhealthplatform.eu/wp-content/uploads/2015/09/Report-the-State-of-Oral-Health-in-Europe.pdf

Petersen, P. E. (2003). The World Oral Health Report 2003: continuous improvement of oral health in the 21st century - the approach of the WHO Global Oral Health Programme. Community Dentistry and Oral Epidemiology, 31(s1), 3–24. https://doi.org/10.1046/j..2003.com122.x

Petersen, P. E., & Lennon, M. A. (2004). Effective use of fluorides for the prevention of dental caries in the 21st century: the WHO approach. Community Dentistry and Oral Epidemiology, 32(5), 319–321. https://doi.org/10.1111/j.1600-0528.2004.00175.x

Petersen, P. E., Bourgeois, D., Ogawa, H., Estupinan-Day, S., & Ndiaye, C. (2005). The global burden of oral diseases and risks to oral health. Bulletin of the World Health Organization, 83(9), 661–669.

Poulsen, S., & Malling Pedersen, M. (2002). Dental caries in Danish children: 1988-2001. European Journal of Pediatric Dentistry, 3(4), 195–198.

Robeaglehole, Myriad Editions, & International Dental Federation. (2009). The oral health atlas : mapping a neglected global health issue. Cointrin, Switzerland: Fdi World Dental Federation.

Rosenblatt, A., Stamford, T. C. M., & Niederman, R. (2009). Silver Diamine Fluoride: A Caries "Silver-Fluoride Bullet." Journal of Dental Research, 88(2), 116–125. https://doi.org/10.1177/0022034508329406

Schuller, A. A., & Holst, D. (1998). Changes in the oral health of adults from Trondelag, Norway, 1973-1983-1994. Community Dentistry and Oral Epidemiology, 26(3), 201–208. https://doi.org/10.1111/j.1600-0528.1998.tb01950.x

Schwendicke, Falk, & Göstemeyer, G. (2017). Cost-effectiveness of root caries preventive treatments. Journal of Dentistry, 56, 58–64. https://doi.org/10.1016/j.jdent.2016.10.016
Seidl, J., Last, J. M., & International Epidemiological Association. (1988). A Dictionary of epidemiology (2nd ed.). New York: Oxford University Press.

Stecksén-Blicks, C., Sunnegårdh, K., & Borssén, E. (2004). Caries Experience and Background Factors in 4-Year-Old Children: Time Trends 1967–2002. Caries Research, 38(2), 149–155. https://doi.org/10.1159/000075939

Szoke, J., & Petersen, P. E. (2000). Evidence for dental caries decline among children in an East European country (Hungary). Community Dentistry and Oral Epidemiology, 28(2), 155–160. https://doi.org/10.1034/j.1600-0528.2000.028002155.x

Tanzer, J. M. (1995). Dental Caries is a Transmissible Infectious Disease: The Keyes and Fitzgerald Revolution. Journal of Dental Research, 74(9), 1536–1542. https://doi.org/10.1177/00220345950740090601

Thomas, B., & Gostin, L. O. (2013). Tackling the Global NCD Crisis: Innovations in Law and Governance. The Journal of Law, Medicine & Ethics, 41(1), 16–27. https://doi.org/10.1111/jlme.12002

Toverud, G. (1949). Dental Caries in Norwegian Children during and after the Last World War. A Preliminary Report. Proceedings of the Royal Society of Medicine, 42(4), 249–258. https://doi.org/10.1177/003591574904200408

Toverud, G. (1957). The Influence of War and Post-War Conditions on the Teeth of Norwegian School Children. II. Caries in the Permanent Teeth of Children Aged 7-8 and 12-13 Years. The Milbank Memorial Fund Quarterly, 35(2), 127. https://doi.org/10.2307/3348364

Vilstrup, L., Christensen, L. B., Hede, B., & Kristensen, S. F. (2010). Tandsundhed for brugere af praksistandplejen i 2000-2008. Tandlaegebladet, 114, 704–712.

Vinten-Johansen, P., & Al, E. (2003). Cholera, chloroform, and the science of medicine : a life of John Snow. Oxford: Oxford University Press.

Watt, R. G. (2007). From victim blaming to upstream action: tackling the social determinants of oral health inequalities. Community Dentistry and Oral Epidemiology, 35(1), 1–11. https://doi.org/10.1111/j.1600-0528.2007.00348.x

<u>Book References:</u>

Dentistry, Dental Practice and the Community, Brian Burt, Stephen Eklund
Burt, B. A., & Eklund, S. A. (2005). Dentistry, dental practice, and the community. St. Louis, Mo.: Elsevier/Saunders.
(Burt & Eklund, 2005)

Essential Dental Public Health, Blanaid Daly, Richard Watt, Paul Batchelor and Elizabeth Treasure
Blánaid Daly, Batchelor, P., Treasure, E. T., & Watt, R. G. (2013). Essential dental public health. Oxford: Oxford University Press.

Public Health, what it is and how it works, Bernard Turnock
Turnock, B. J. (2012). Public health : what it is and how it works. Burlington, Ma: Jones & Bartlett Learning.
(Turnock, 2012)

Principles of Dental Public Health, James Morse Dunning
James Morse Dunning. (1986). Principles of dental public health. Cambridge, Mass.: Harvard University Press.

CAMBRA, SDF, and Philosophies of Dental Health Care

(Dr. Josh Even, DMD)

As dental health care providers we can agree that in order to tackle dental disease we have to focus on the cause instead of the effect. It's almost a cliché now to say that we cannot 'drill and fill' our way out of the dental caries problem, and that caries is a 'multifactorial disease'. Surgical intervention is not the way to make our patients healthier, and yet, the majority of dental offices in the United States are designed to support such a practice. In order to effectively treat caries, we have to identify and address the behaviors, biochemistry, and complex interplay of other variables. There are established risks for caries that are balanced by established protective factors. This interplay is unique for every patient, so therefore each patient should have an individualized caries risk-based treatment plan.

The concept of CAMBRA is explained by its very definition. Caries Management By Risk Assessment is an acceptance that we must treat the disease by treating the risk. It's not enough to diagnose the disease, caries, in a patient's mouth. A dentist should be analyzing the patient's risk factors, weighing those risks against a patient's protective factors, and establishing a net risk diagnosis. That's the 'Risk Assessment' part of CAMBRA.

The 'Caries Management' part is implementing a series of evidence-based treatment guidelines that are specific for a risk diagnosis. These guidelines prescribe the best treatment options for various facets of a patient's individualized treatment plan. If the goal is to treat the patients' active disease, and actively reduce their risk for further disease, then the application of established therapies to treat the patient's caries risk through CAMBRA is the method of achieving that goal.

The Philosophy of CAMBRA: A Case for Accountable Care

CAMBRA can be thought of as a philosophy. One cannot imagine any dentist admitting they do not consider a patient's disease state or risk for caries when developing a treatment plan. And yet, there is a divide between the concept of this consideration and how to apply it every day in one's clinical practice. Before the specifics of CAMBRA are discussed, and specifically how Silver Diamine Fluoride can become a pivotal treatment within the CAMBRA framework, there needs to be an elucidation of two differing treatment philosophies. Consider a new patient who presents to a typical dentist with a toothache. This dentist is similar to the majority of dentists in the United States, in that he or she has some portion of their compensation determined by the procedures completed that day. For sake of simplicity, this model of dental care, where the provider either bills or is reimbursed for procedures will be described as fee-for-service. Whether it's entirely the patient, or their third-party payer, or a combination of both, the dentist is being compensated based on the procedures completed.

If this dentist is in small town office with a single provider or a large multi-specialty group practice owned by a private corporation, when this patient comes in seeking relief, the expected treatment plan could be similar. Assume the patient is diagnosed as having irreversible pulpitis due to a large carious lesion. The dentist would not be criticized for recommending root canal therapy to alleviate the symptoms and treat the affected tooth. If they have time, they would also not be criticized for initiating and (if possible) completing this treatment on the very same visit. Furthermore, it would be likely that the next recommended treatment for that tooth would be full cuspal coverage to reduce the risk of fracture.

While this comprehensive treatment plan would certainly take care of the patient's chief complaint, treating this patient, this tooth, in this way is not managing dental disease. In fact, for this patient presenting with a large carious lesion, the prognosis of that final restoration may be very poor if the underlying factors affecting his or her risk for tooth decay are not addressed. Would the patient's chief complaint not also be addressed by performing far less complicated and expensive treatment (a pulpotomy, for example) so the dentist and patient could focus on treating the dental disease by implementing CAMBRA? Then, once the risk level is diagnosed and treated (if appropriate), the long-term prognosis of any restorative procedures would be improved.

In a typical fee-for-service dental practice, where the provider's primary economic driving force is production, the goal in this scenario might be the more expensive and invasive treatment, even if the long-term outcome is compromised. When one is being reimbursed based on procedure, there's not a lot of money in prevention. To truly embrace CAMBRA in a dental practice, the fundamental mechanisms of how that practice operates must be aligned in such a way as to reinforce the concept of dental health care, rather than traditional fee-for-service dentistry.

This alternative philosophy to traditional fee-for-service dentistry could be described as a Dental Accountable Care Organization, or DACO. In 2013, the American Dental Association published a research brief describing the advent of Accountable Care Organizations (ACOs) within the context of a changing health care landscape. At the time, the idea was that dental care could be delivered as part of a comprehensive medical ACO, linking dental care to whole health care.

The reality is that there are independent dental health care organizations that operate as ACOs. An ACO in the dental world is fundamentally no different than a traditional medical ACO, meaning that it is fully accountable for care and total costs for all of its members. Rather than a third-party payer reimbursement model, or direct payment for procedures, the DACO is both insurer and provider, responsible for the entirety of patients' dental health care. In this model of care delivery, the staff is employed by the group dental practice, and its individual clinics are carefully aligned and supported to ensure provider teams are delivering consistent and effective patient care.

These organizations are uniquely positioned to shape their clinical practices to meet the goal of fulfilling the "Quadruple Aim," as an evolution of the "Triple Aim" set forth in the Patient Protection and Affordable Care Act. The concept of the Quadruple Aim, much like CAMBRA, while widely accepted as a goal, is not realistically attainable unless a practice is organized in a very specific way to meet it. The Quadruple Aim is the simultaneous achievement of improving quality of care (including the population's access to health care) and patient health, while reducing cost and encouraging an enriching environment for the providers at every level. It is truly a model

where 'everybody wins' if the business model of the organization is aligned with what is in the patients' best interest: health and happiness. As opposed to traditional fee-for-service dentistry, a DACO's business model is compatible with the concepts emphasized in modern medicine's Quadruple Aim.

One key concept of CAMBRA is that the most effective methods of treating caries risk are ultimately the patients' responsibility. Patients must understand the treatment plan and accept their part in it. While we have very powerful tools to use in the dental office (Silver Diamine Fluoride, for example), without the proper self-care, the reduction in caries risk will not be as successful in the long term. In order for CAMBRA to be effective, there is a tremendous reliance on patient adherence to their treatment plan. The DACO model recognizes that one method of building a strong relationship that can be leveraged to improve the health of patients is through a therapeutic alliance, or a partnership between patients and clinicians, including support staff. This philosophy can blur the lines of traditional structure within the clinical staff, empowering providers at every level—dentists, dental hygienists, dental assistants, and front-office staff—to create this new, patient-centered clinical team in order to deliver the best care possible. This team-based model of patient-centered care offers every member the opportunity and responsibility to positively affect the patient's dental health. At every stage of a patient's experience—from the initial exam to the recall reminder—the focus remains on the patient's health literacy and engagement in the process.

The offices must also be supported by technology and systems, with an attempt to standardize the patient experience as much as is practical. If the goal is the Quadruple Aim, the tools, training, support, and measures must help providers achieve it. Additionally, if the DACO removes the financial incentive from the equation, in as much as the providers are not reimbursed for procedures, the organization must develop new metrics to incentivize clinicians. This allows for creative processes that will emphasize the core values of the organization and importance of preventive patient-centered dental health care.

To align provider goals with the Quadruple Aim, measures need to be created and metrics developed that constitute a new provider incentive matrix. These goals can be very specific for each aim. Most important is that the clinical teams are aware of the global impact their efforts can have on patients and their dental health. A DACO must further differentiate itself from traditional dentistry by measuring the quality of care provided and outcomes of that care. This lofty goal can only be accomplished with a robust electronic record, standardized risk assessment tools, evidence-based clinical guidelines, universal adoption of diagnostic terms, enhanced patient education and engagement, and strategies to ensure that patients adhere to their treatment plan and return for appropriate follow-up.

CAMBRA as Part of Clinical Operations Design

This is where we get back to CAMBRA, as it becomes the core of the evidence-based guidelines that a DACO should use to structure a large portion of its clinical practices and performance measures. Although it will not be discussed further, it should be noted that while CAMBRA can be employed as a means to treat the dental disease caries, there should also be evidence-based practice guidelines and measures around periodontal disease management, as well as Quadruple Aim based measures such as access to care, employee satisfaction and engagement, budgeting, and patient satisfaction.

Implementing CAMBRA at a practice can be a significant undertaking, the difficulty of which is amplified by the size of the practice. There must be an investment of resources to ensure proper operational design, including specific workflows within an electronic dental record, training in the use of these new processes and workflows, and continuous support and analysis of the operational practices of the clinicians. The feasibility of implementation is wholly dependent on the flexibility of the software system employed at the clinics. It would be ideal to begin with the end in mind, especially if a practice is in a position to pick a software system that could be leveraged to help with the training, implementation, and continuous data analysis needed to successfully implement and sustain any practice guideline.

Every member of the clinical team should receive training in not just the science and history of CAMBRA, but how to relate those concepts to their everyday practice. The complex CAMBRA clinical guidelines (discussed later) can be adapted to the practice, distilled into simple graphics, and paired with the codes and protocols the clinicians are familiar with. Clinical decision support can be built into the electronic record to not only auto-calculate caries risk level, but to present the clinician with shortcuts to 'bundle' treatments based on the established CAMBRA clinical guidelines. Additionally, standardized patient-facing documents can be developed to help the clinical team partner with the patients in their oral health care.

Within the electronic dental record, real time tracking can be developed and implemented immediately to further reinforce the practice guidelines at a per-patient level. The providers' performance metrics should be designed to reflect these new practice guidelines, as well. There is now an opportunity for CAMBRA to be embraced so comprehensively that the dentists can be incentivized on how well their treatment aligns with the CAMBRA treatment guidelines.

To be clear, every metric and guideline must still depend on the dentist's chosen caries risk diagnosis. Even though it is possible to have an automatic calculation of caries risk be generated by the electronic dental record software, the autonomy of the dentist must be preserved. While there can be embedded clinical decision support to *suggest* a diagnosis to the provider based on information entered into the electronic chart, the actual recorded diagnosis should be entered by the dentist.

Additionally, notifications can be designed to alert the provider to potential inappropriate treatment. This kind of clinical decision support is often utilized in electronic medical chart software. These flags in no way prevent a provider from planning a course of treatment that they determine to be in the patient's best interest. For example, thinking back to the earlier clinical example, a flag could be raised in the software if the dentist entered in a procedure code for a crown in a patient who had not had a comprehensive exam. Without the caries risk and periodontal condition assessed and recorded, the computer simply doesn't know if the treatment would be appropriate, as much of the diagnostic information is missing. With respect to CAMBRA, is there more active decay? Does the patient have other significant risk factors for caries? If we consider the periodontium, what is the condition of the supporting structures**?** If it is established that the patient has other dental disease or significant risk for dental disease, the prognosis for this treatment (the root canal itself, or full coverage of the root canal treated tooth) could be very poor, or potentially contraindicated.

Again, thinking back to our earlier scenario, one could imagine many scenarios where the root canal and crown are the proper course of treatment and in the patient's best interest. The software should always allow the dentist to quickly override the decision support and document the rationale. Ideally the software will remind the provider of the need for proper diagnosis and treatment planning. Implementing CAMBRA in this way should be reinforced at every step of the treatment planning process, with the intention of helping the clinician record a complete and valuable record, including disease risk and diagnosis, and grounding the treatment in the best evidence-based guidelines.

The CAMBRA Clinical Guideline

CAMBRA, as a clinical practice philosophy, is a continuum of care that defines a practice guideline. The process begins with a comprehensive exam and thorough data collection, continues with a risk assessment, diagnosis and appropriate treatment, and circles back to the beginning with recall exams and updated data. Using the established CAMBRA treatment guidelines, one can standardize treatment (as it relates to caries) based on risk to encompass all aspects of this care continuum. The CAMBRA clinical guideline describes recommended treatments (both in and out of the dental office) and recall intervals based on caries risk level.

The CAMBRA guideline, then, because it is so specific and structured, is easily adapted to become a core part of a practice philosophy. The aforementioned DACO's structured integration of CAMBRA should begin with the comprehensive exam. Each patient would be expected to have a caries risk assessment completed at the comprehensive exam (typically the 'new patient' exam, or at routine follow-up comprehensive exam visits). The CAMBRA caries risk assessment tool is a comprehensive collection of questions designed to help the provider come to an overall risk assessment. In the electronic dental chart, the CAMBRA caries risk assessment is captured within an electronic form. Real-time analysis within the software can make sure this part of the chart is completed, stamped with the same date as the exam code. This piece of necessary chart information can be part of a larger automatic chart-audit process, with the results fed back to the provider in real time. By checking the 'score' of the current patient's chart, the provider is alerted to any data fields that may need to be updated or included If possible, an algorithm within the dental software could automatically calculate a 'suggested' caries risk based on how the clinician filled out the CAMBRA risk assessment form. Again, the autonomy of the clinician must be protected, so it is advisable to have the provider use this calculated risk diagnosis as clinical decision support, and enter their own formal risk diagnosis.

Based on the chosen caries risk level the dentist can now plan treatment according to the

CAMBRA intervention guidelines. The chart below shows a summary of the CAMBRA clinical guidelines and is not meant to describe any one organization's actual clinical protocol. Note that each row of the intervention guide shown below describes the ideal treatments for that risk level.

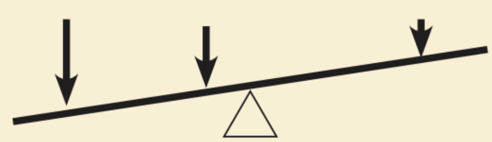
Caries Risk Assessment Form — Children Age 6 and Over/Adults

Patient Name: ______________________________ Chart #: ______________ Date: ______________________

Assessment Date: Is this (please circle) baseline or recall

Disease Indicators **(Any one "YES" signifies likely "High Risk" and to do a bacteria test**)**	**YES = CIRCLE**	**YES = CIRCLE**	**YES = CIRCLE**
Visible cavities or radiographic penetration of the dentin	YES		
Radiographic approximal enamel lesions (not in dentin)	YES		
White spots on smooth surfaces	YES		
Restorations last 3 years	YES		
Risk Factors (Biological predisposing factors)		YES	
MS and LB both medium or high (by culture**)		YES	
Visible heavy plaque on teeth		YES	
Frequent snack (> 3x daily between meals)		YES	
Deep pits and fissures		YES	
Recreational drug use		YES	
Inadequate saliva flow by observation or measurement (**If measured, note the flow rate below)		YES	
Saliva reducing factors (medications/radiation/systemic)		YES	
Exposed roots		YES	
Orthodontic appliances		YES	
Protective Factors			
Lives/work/school fluoridated community			YES
Fluoride toothpaste at least once daily			YES
Fluoride toothpaste at least 2x daily			YES
Fluoride mouthrinse (0.05% NaF) daily			YES
5,000 ppm F fluoride toothpaste daily			YES
Fluoride varnish in last 6 months			YES
Office F topical in last 6 months			YES
Chlorhexidine prescribed/used one week each of last 6 months			YES
Xylitol gum/lozenges 4x daily last 6 months			YES
Calcium and phosphate paste during last 6 months			YES
Adequate saliva flow (> 1 ml/min stimulated)			YES
****Bacteria/Saliva Test Results: MS: LB: Flow Rate: ml/min. Date:**			

VISUALIZE CARIES BALANCE
(Use circled indicators/factors above)
(EXTREME RISK = HIGH RISK + SEVERE SALIVARY GLAND HYPOFUNCTION)
CARIES RISK ASSESSMENT (CIRCLE): EXTREME HIGH MODERATE LOW



Doctor signature/#: ____ Date: ____________________

The actual clinical guideline of a practice should be designed to present as much information as possible in a format that is easy to digest and actualize in the clinical practice. The guidelines should show in stepwise order the ideal treatment for a patient presenting with a specific caries risk. It should show treatment recommendations for the initial exam appointment, indicate what, if any, prescriptions or home care products are recommended, and when the patient should return for a follow-up appointment (refer to table on page 104 for example).

There is a specific requirement for chemotherapies at each caries risk level. It's not enough to drill out carious lesions and expect the patient's risk will decrease. Whatever risk factors promoted the development of caries in the patient's mouth are likely going to continue. This puts the patient at elevated risk for further decay. Patients with active caries, or at elevated risk for caries are really being diagnosed as 'out of balance'. There is a delicate interplay between the host and bacteria within the ecosystem of the oral cavity. This, along with the external modifiers of dental disease (diet, homecare, etc.), needs targeted treatment with the intent of regaining 'balance' and lowering the patient's risk for caries.

There are different chemotherapies identified in the CAMBRA treatment guideline. These represent the need to fulfil the two therapeutic goals of remineralizing damaged tooth structure and reducing the pathogenic bacterial load. At the time of CAMBRA's inception, one antimicrobial option that was recommended was chlorhexidine gluconate, used as a mouthwash as part of a specific regimen.[7] Like many aspects of the CAMBRA treatment guideline, it is not just the use of a therapy but the very specific use, in a very specific way that was validated. While adult patients with Moderate Risk are typically prescribed a strong fluoride toothpaste, patients with High Risk are prescribed both the strong toothpaste and chlorhexidine gluconate mouthwash. The CAMBRA regimen for chlorhexidine mouthwash is to instruct the patient to rinse every night before bed for one week and NOT use the prescription toothpaste at night. Then, for the next three weeks the patient would not use the chlorhexidine mouthwash (they would be instructed to just use their prescription-strength fluoride toothpaste at night). This cycle would continue: one week of chlorhexidine followed be three weeks without until the patient's next re-evaluation visit. The intent behind the staggered chlorhexidine treatment is to culture more benign, early colonizing bacteria in the dental plaque.

Leveraging the important recent studies that support the use of Silver Diamine Fluoride (SDF) as a caries treatment and management tool, the CAMBRA intervention guideline should be re-interpreted as SDF is utilized in an increasing number of clinical practices. SDF acts as both remineralizing and antimicrobial agent. To replicate the intent of the staggered chlorhexidine regimen in CAMBRA, an updated guideline could suggest three SDF applications spaced out within the first three months for High Risk patients. A balance should be attempted to make the therapies as effective and easy to implement as possible. In reality, the recommended chlorhexidine regimen as described in the original CAMBRA clinical guidelines may be difficult to explain to patients, just as it is difficult to ascertain if the patient had dutifully adhered to the protocol in the months between visits. The addition of SDF to the clinical protocol should make proper antimicrobial therapy more reliable, as the treatments are administered in office.

SDF can also greatly improve the dentists' effectiveness in providing minimally invasive restorative procedures to preserve as much tooth structure as possible. SDF, glass ionomer, and Silver Modified Atraumatic Restorative Technique (SMART) restorations fit perfectly into the CAMBRA protocol, as these treatments not only directly treat the local carious lesion, but have the potential to lower the patient's risk for developing future lesions.

For most patients diagnosed as having elevated risk, part of the treatment plan should include a follow-up visit. This is not the routine comprehensive exam as described earlier, but a more risk-specific re-evaluation. This visit is critical to assess the patient's engagement in their health care plan. This short visit, often with the dentist's auxiliary staff members, can be leveraged as another touchpoint along the patient's health care journey. Their compliance with recommended self-care instructions can be assessed, and focused treatments (SDF and fluoride varnishes, for example) can be administered. Rather than have every patient, independent of risk or disease state, be advised to return for exam visits every six months, as is the *de rigueur* practice in many traditional dental offices, the CAMBRA clinical guidelines can reinforce the concept of delivering the appropriate treatment to the appropriate patient at the appropriate time.

As with the comprehensive exam, the caries risk assessment digital form should be updated at the caries risk recall appointment, and the patient's caries risk level calculated again. By entering the patient's caries risk level at different points in time (with the recall interval prescribed by the CAMBRA Intervention Guideline), data about the longitudinal change in risks and health levels can be captured for every patient.

A Case for CAMBRA and the Dental Accountable Care Organization

Caries management by risk assessment should be considered the gold-standard for the medical management of caries. In order for this philosophy of treating dental disease to be widely adopted, there must be a fundamental rethinking of the methods in which dental care is delivered in the Unites States. If the goal is true dental health care, then the mechanisms by which that care will be delivered must be designed to support it. This means a fundamental re-thinking of the economics of dental health care, on both the provider and patient side.

By contemplating the design of a dental health care system that not only allows for the routine implementation of evidence-based methods of treating dental disease, but actively encourages it, one can see how this alternative to the traditional fee-for-service model is positioned to meet the Quadruple Aim.

RISK CATEGORY	RECARE EXAM	RADIOGRAPHS	SALIVA TESTING	FLUORIDE
LOW	6+: Every 6-12 months <6: Annual	6+: BWX every 24-36 months <6: BWX every 12-24 months	6+ & <6: Optional at baseline exam	6+ Home: OTC toothpaste 2x daily 6+ In-office: F varnish optional <6 Home: OTC toothpaste; no in-office fluoride
MODERATE	6+: Every 4-6 months <6: Every 3-6 months	6+: BWX every 18-24 months <6: BWX every 6-12 months	6+ & <6: Recommended at baseline and recare exams	6+ Home: OTC toothpaste 2x day + OTC 0.05% NaF rinse daily 6+ In-office: Initially 1-3 applications F varnish & at recare appt. <6 Home: OTC toothpaste 2x day <6 In-office: F varnish initial visit & recare Caregiver: OTC NaF rinse
HIGH 1 or more cavitated lesions is considered high risk	6+: Every 3-4 months <6: Every 1-3 months	6+: BWX every 6-18 months <6: Anterior PAX & BWX every 6-12 months	6+ & <6: Required at baseline and recare exams	6+ Home: 1.1% NaF toothpaste 2x day 6+ In office: Initially 1-3 applications F varnish & at recare appt. <6 Home: OTC toothpaste 2x day <6 In-office: F varnish initial visit & recare Caregiver: OTC NaF rinse
EXTREME (High risk plus dry mouth or special needs) 1 or more cavitated lesions plus hyposalivation is considered extreme risk	6+: Every 3 months <6: Every 1-3 months	6+: BWX every 6 months <6: Anterior PAX & BWX every 6-12 months	6+ & <6: Required at baseline and recare exams	6+ Home: 1.1% NaF toothpaste 1-2x day & 0.05% NaF rinse when mouth feels dry & especially after eating or snacking 6+ In office: Initially 1-3 applications F varnish & at recare appt. <6 Home: OTC toothpaste 2x day <6 In office: F varnish initial visit & recare Caregiver: OTC NaF rinse

Adapted from: Jenson L, Budenz AW, Featherstone JDB, Ramos-Gomez FJ, Spolsky VW, Young DA. Clinical protocols for caries management by risk assessment. J Calif Dent Assoc. 2007;35(10):714-723.

RISK CATEGORY	XYLITOL	ANTIMICROBIALS, i.e., Chlorhexidine	CALCIUM PHOSPHATE	SEALANTS (Resin-based & Glass Ionomers)	pH Neutralizing
LOW	6+ & <6: Optional	6+: If required <6: No	6+ & <6: If required Optional for root sensitivity (adults)	6+: Optional on sound tooth surfaces <6: Optional on sound tooth surfaces	6+: If required <6: No
MODERATE	6+: 6-10 grams/day <6: Xylitol wipes & substitute for sweet treats or when unable to brush Caregiver: 2 sticks of gum or 2 mints 4x day (in total 6-10 grams of xylitol per day)	6+: If required <6: Recommend for caregiver	6+: If required Optional for root sensitivity (adults) <6: Brush with smear (0-2 yrs) or pea size (3-6 yrs) 1x day, leave on at bedtime	6+: Optional on sound tooth surfaces <6: Fluoride-releasing sealants or glass ionomers on deep pits and fissures	6+: If required <6: No
HIGH 1 or more cavitated lesions is considered high risk	6+: 6-10 grams/day <6: Xylitol wipes & substitute for sweet treats or when unable to brush Caregiver: 2 sticks of gum or 2 mints 4x day	6+: 0.12% CHX gluconate 10 ml rinse for 1 minute/day for one week each month Antimicrobial therapy should be done in conjunction with restorative treatment as needed <6: Recommend for caregiver	6+: If required <6: Brush with smear (0-2yrs) or pea size (3-6 yrs) 1x day, leave on at bedtime	6+: Recommended <6: Fluoride-releasing sealants or glass ionomers on deep pits and fissures	6+: If required <6: No
EXTREME (High risk plus dry mouth or special needs) 1 or more cavitated lesions plus hyposalivation is considered extreme risk	6+: 6-10 grams/day <6: Xylitol wipes & substitute for sweet treats or when unable to brush Caregiver: 2 sticks of gum or 2 mints 4x day	6+: 0.12% CHX gluconate 10 ml rinse for 1 minute/day for one week each month Antimicrobial therapy should be done in conjunction with restorative treatment <6: Recommend for caregiver	6+: Apply paste several times daily <6: Brush with smear (0-2yrs) or pea size (3-6 yrs) 1x day, leave on at bedtime	6+: Recommended <6: Fluoride-releasing sealants or glass ionomers on deep pits and fissures	6+: Acid neutralizing rinses/gum/mints if mouth feels dry, after breakfast, snacking, & at bedtime <6: No

Ramos-Gomez F, Crystal YO, Ng MW, Crall JJ, Featherstone JDB. Pediatric dental care: prevention and mangaement protocols based on caries risk assessment. J Calif Dent Assoc. 2010;38(10):746-761.

Section Three: Clinical Applications of the Medical Management of Caries and SMART Restorations

A Pioneer in the Trenches

(Dr. John Frachella, DMD)

Dr. John Frachella and pal, Sevin.

What is SMART?

SMART is "Silver Modified A-traumatic Restorative Treatment". It provides an efficient, preventive, and low -cost way to control caries. It involves applying liquid silver ions in the form of aqueous silver fluoride (AgF), silver nitrate (SN) or silver diamine fluoride (SDF) to partially excavated or unexcavated decay followed by sealing with glass-ionomer cement (GIC) or resin modified glass- ionomer (RMGI). SMART is a minimally invasive form of the medical management of caries.

Evidence for the Benefits of Minimally Invasive Dentistry:

It well known that the caries process in some lesions is actually reversible by using topical fluorides, aqueous silver ion solutions, GIC, RMGI and even certain peptides (*Yamagishi et al., 2005*) (*Pitts, 2013*). *(Milsom, Blinkhorn, & Tickle, 2008) (ten Cate, 2013) (Featherstone, 2003) (Mellberg, 1988) (Featherstone, 2000) (Mount, 2005).* At all stages in the development of the caries process (even when there's cavitation), it is also possible for re-mineralization cycles to return (*Mount, 2002*). Aggressive invasive dentistry does not cure dental disease. In fact, invasive drilling and filling can often lead to a continual process of fillings being replaced followed by cavities getting larger and teeth getting weaker. The G. V. Black philosophy of "Extension for prevention" has been shown to be overly aggressive and ultimately destructive. A study published in JADA in 2017 shows that children who receive increasing amounts of surgical dental care show little improvement in future caries prevention (*Dye, Mitnik, Iafolla, & Vargas, 2017*).

In its earlier history, the profession of dentistry strongly supported minimally invasive treatment measures over more invasive ones. In 1890, Dr. W. D. Miller proved that dental caries is a bacterial infection capable of being arrested by silver nitrate (SN). In 1908, G. V. Black ("The Father of Modern Dentistry") promoted SN to arrest caries "as a first measure against the disease". In 1938 the ADA Council on Dental Therapeutics officially announced that "silver ions arrest caries lesions". And in 1950, Dr. Percy Howe, president of the ADA, Founder of the Forsyth Institute and dean of Harvard Dental School used SN to treat caries *before* he used needles and drills and he actually marketed it as "Howe's Solution" which was sold via ads in the 50's in JADA.

After the 50's minimally invasive dentistry took a back seat to community water fluoridation which looked like a panacea against caries. But fluoride in community water wasn't effective in combating the caries epidemic that began before 1950 and which has grown exponentially since.

Almost all restorative materials used in invasive dentistry, including composite resins which were introduced in the 60's, are inert showing no biologic activity in relation to tooth structures. Exceptions include amalgam (which corrodes in teeth releasing silver ions that deter recurrent decay) and silicate cements (that release fluoride ions, but which also cause tooth sensitivity). During the 60's, researchers such as Massler, Fusayama and Brannstorm wrote detailed papers on a relatively new science called "tooth de-mineralization and re-mineralization". Thus, began the exploration of the power of mineral ion-exchanges in the healing of decayed teeth without the need for surgical intervention (*Mount, 2002*).

In 1976, glass-ionomers were introduced to the worldwide dental market. By then, an increasing number of researchers began studying the exchange of mineral ions both in and out of teeth as influenced by saliva, the application of aqueous silver ions and the application of mineral ion-releasing glass-ionomer cements. Coincidentally, in 1978, Dr. Graham Craig, an Australian dental educator working in the Outback, found it difficult to drill and fill teeth in indigenous children because they'd bad previous dental experiences at the hands well-meaning dentists on humanitarian missions. Necessity became the mother of invention for Dr. Craig as he pioneered the use of aqueous silver fluoride used together with GIC to desensitize painful teeth, re-mineralize decayed tooth structures, arrest decay without needles or drills and without complete decay excavation (*Craig & Powell, 2013*). After that it would be a very long time indeed before anyone else would regularly employ silver ions and glass ionomers in combination to successfully treat caries.

In 1996, another giant step was taken in advocating for minimal invasion when Dr. Jo Frencken, a dentist from the Netherlands, introduced a concept called "A-traumatic Restorative Treatment" (ART) in which caries is partially excavated with hand instruments then covered immediately with GIC. Remarkably, this caught the attention of the World Health Organization who, in 1998, recommended ART as the "first line of treatment for primary teeth, worldwide" (*WHO Collaboration, 1998*).

In 2001 the American Academy of Pediatric Dentistry jumped on the bandwagon by adopting their very own modified version of ART, re-naming it ITR (Interim Therapeutic Restoration). Then, a decade after the WHO's bold endorsement of ART, it was proven repeatedly that removing all vestiges of infected dentin from lesions approaching the pulp is not required for caries management (van *Thompson, Craig, Curro, Green, & Ship, 2008*) (*D Ricketts, Kidd, Innes, & Clarkson, 2009*) (*Chibinski, Reis, Kreich, Tanaka, & Wambier, 2013*).

Evidence for Doing SMART:

Today, there is ample evidence for each of the following key components of SMART:

1) Partial caries removal vs. complete removal

2) Antimicrobial and re-mineralizing effects of SDF

3) Antimicrobial and re-mineralizing effects of GIC and RMGI

There is also evidence for the re-mineralizing efficacy of SDF and GIC used separately as indirect pulp capping materials (*Shah, Gupta, Sinha, & Logani, 2011*).

Since silver and fluoride ions and glass-ionomer cements are primarily water-based and compatible with each other, it makes sense that their combination would create increased mineral ion release while providing anti-bacterial and re-mineralizing therapy. This has been corroborated repeatedly by evidence of positive outcomes existing in tens of thousands of dental charts of patients treated with SMART (from as far back as 1978 in the case of Dr. Craig). Clinical outcomes show highly effective caries reduction and prevention with the use of aqueous silver and fluoride ions sealed inside active lesions with glass-ionomer cements. As a cautionary note it is also important to recognize that it is highly unlikely any kind of restoration or restorative material will ever prove effective in preventing *all* further caries in patients.

ART, ITR and SMART :

All three of these techniques modify bacterial flora and are more conservative, less costly and better tolerated by patients who suffer from the fear of needles and drills. Furthermore, GIC used in ART, ITR and SMART has been shown to prevent recurrent caries in treated teeth as well as in teeth adjacent to those treated (*Cagetti et al., 2014*) (*Hicks, Garcia-Godoy, Donly, & Flaitz, 2003*). Of these three minimally invasive restorative techniques, SMART is the only one that uses silver ions and GIC or RMGI in combination to provide a potentially higher standard of restorative and preventive care. That said, it is important to recognize that GIC used alone can very effectively treat caries with zero or minimal decay excavation due to its high fluoride release (*Berg, 2002*). Fluoride-releasing GIC restorations when used alone have been shown to inhibit the lateral spread of caries as well as the spread of occlusal and interproximal caries while simultaneously providing a caries protective effect for cavo and adjacent surfaces (*Hicks, Garcia-Godoy, Donly, & Flaitz, 2003*). Also, GIC and RMGI have been shown to actually re-mineralize de-mineralized dentin (*Ngo, Mount, Mc Intyre, Tuisuva, & Von Doussa, 2006*) and GIC restorations show less recurrent decay than amalgams after 6 years (*Steffen Mickenautsch & Yengopal, 2012*). In one study, GIC sealants helped to protect against caries 4X better than resin sealants (*Beiruti, Frencken, van't Hof, Taifour, & van Palenstein Helderman, 2005*) while also protecting newly erupted teeth from developing caries lesions (*Barja-Fidalgo, Maroun, & de Oliveira, 2009*). One study done with 2,557 seven-year-old children showed that GIC used alone on occlusal surfaces prevents caries interproximally (*Cagetti et al., 2014*). Also, GIC provides a permanent chemical-bond at the tooth surface, not a semi-permanent micromechanical, resin-tag-bond (*Mount, 2002*). Glass ionomers continually release fluoride and re-charge with more fluoride from fluoridated toothpaste while also being ideal to use in a hydrophilic environment because they are recommended to be applied onto moist tooth surfaces, a situation that favors the treatment of phobic patients who have trouble tolerating dry field techniques. Also, glass ionomers are biocompatible with tooth structure since their thermal expansion is equal to that of dentin. When used properly according to manufacturer's recommendations and with appropriate adherence to the principals of its chemistry, glass ionomer is often a better adhesive material than resin with better chemical bond effectiveness (*Peumans et. al., 2005*). Finally, GIC becomes enamel-like and extremely hard and glassy 2 years after placement unlike any other dental restorative material in use today (*Van Duinen, Davidson, De Gee, & Feilzer, 2004*).

Glass-Ionomers Create a Permanent Acid-Resistant Zone of Chemical Fusion on Tooth Surfaces :

The molecular cross-linking of GIC and RMGI to dentin and enamel (via water-based ionic transfer) creates a *permanent acid-resistant zone of chemical fusion at the tooth surface* - whether the glass-ionomer is "retained" or not. The X-rays shown in **Figure 1** (below) were provided by Dr. Martin Macintyre, a US dentist. GIC was placed over unexcavated decay on the mesial and occlusal surfaces of #S when the patient was 5 years old. The child was re-examined when he was 7 years old and it was discovered that the GIC had fallen out. Regardless, the GIC had already re-mineralized the decay in #S and also reduced the size of the caries lesion on the mesial surface of #T with no other medical or surgical intervention employed to achieve that result.

In this case, the metric for success based on "retention" is inherently flawed because the teeth in question in are decay-free regardless of retention. A chemically fused zone was created by GIC formed at the GIC- tooth interface which protected that interface from future decay even when the GIC was lost. In the process of creating this acid-resistant interface, calcium, phosphorous, fluoride, aluminum and strontium

Figure 1.

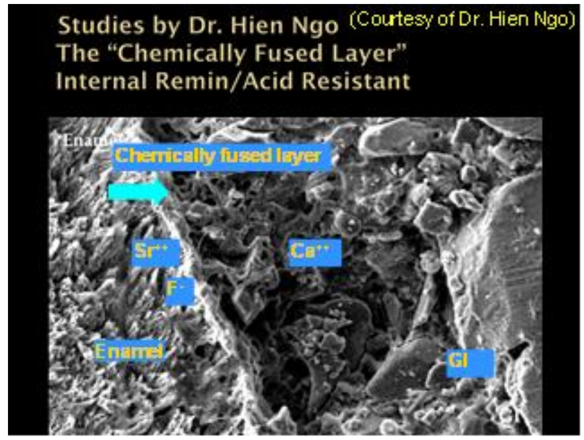


Figure 2.

Figure 3.

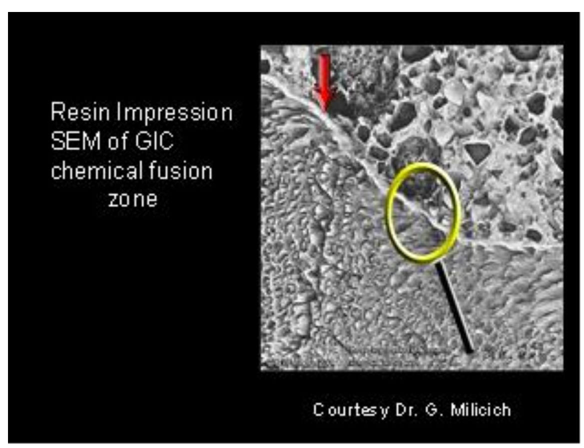


Figure 4: A resin impression SEM technique for examining the glass–ionomer cement chemical fusion zone (Milicich, 2005).

ions transferred through the patient's saliva from the glass to the tooth and from the tooth to the glass as seen in **Fig 2, 3 and 4** (*H. Ngo, Ruben, et al., 1997*).

SDF Combines Fluoride Ions and Silver Ions:

SDF aggressively re-mineralizes and is also an antibiotic liquid (*Horst, Ellenikiotis & Milgrom, 2016*). SDF outperforms all other anti-caries medicaments in killing cariogenic bacteria (*M. L. Mei, Lo, & Chu, 2018*) (*Rosenblatt, Stamford, & Niederman, 2009*). We do not have evidence that SDF kills *all* caries-causing bacteria, but there is solid data showing that SDF slows down the caries process (*references for this are throughout this textbook)*. That said, even as this textbook goes to press, research is starting to disentangle the synergy of silver ions + fluoride ions (*Huang, Shahid & Anderson, 2019*). Integrating silver ions into dentin after it has de-mineralized keeps decay-causing microbes at bay. Fluoride makes it more difficult for dentin in the process of re-mineralizing to de-mineralize again. For example, SDF prevented the primary tooth in **Fig 5** from becoming infected and it re-mineralized the tooth sufficiently enough to prevent it from needing surgical drill and fill dental treatment before it exfoliated at the appropriate age without further intervention.

Figure 5.

Simultaneously combining the application of SDF with the application of GIC restores function by eliminating food traps in teeth while also facilitating the natural exfoliation of primary teeth. Below (**Fig 6+7)** shows an example of a primary molar that was treated with SDF and GIC in a "Same-Day SMART" appointment where SDF+GIC were applied sequentially, 1.5 years before the tooth exfoliated naturally. Cavitation caused by caries was filled, partially excavated decay eventually re-mineralized, decay-causing bacteria were slowed down in their path of destruction, underlying tooth structures became sclerotic and glass-like, and no surgical

Figure 6.

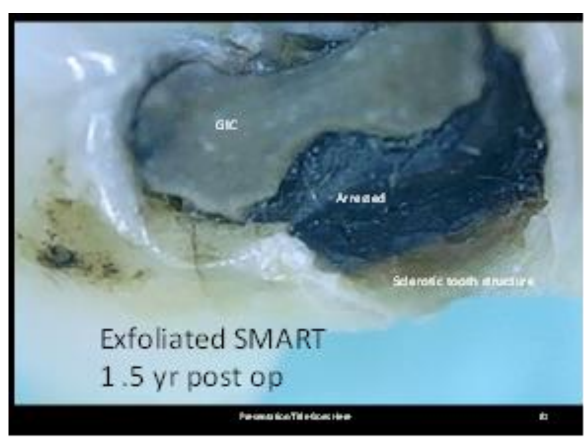


Figure 7.

interventions, no injections of local anesthesia and no use of dental drills and burs were employed.

Two Treatment Timelines for Doing SMART:

1) Multiple day SMART: Apply SDF multiple times over multiple appointments to assure yourself that caries is arrested, and then apply GIC or RMGI over the arrested decay.

2) "Same Day SMART": Fully saturate the lesion(s) with SDF just once then immediately apply GIC, RMG over that single application of SDF.

SMART Protocols

One-surface:

Note 1: Do not attempt SMART on a tooth that is cariously involved to the point of irreversible pulpitis, or if there's evidence of a periapical abscess, purulence or necrosis.

Note 2: This protocol is the same whether applying SDF multiple times over multiple appointments before applying GIC or RMGI or if doing Same-Day SMART .

1) Apply pumice (not prophy paste) with a rubber cup to remove the pellicle.

2) Isolate and scoop all mush and, if possible, also scoop the outer layer of leathery carious dentin caries from the perimeter of the lesion with a small spoon excavator or a round bur on a slow speed handpiece to remove plaque, food particles and any outer layer of decay that is loose. Local anesthesia is NOT to be used, so when doing this, if a patient registers sensitivity, don't scoop or drill any more. Skip this step altogether if there are any suspicions that the pulp is nearby.

3) If worried about leaving a high restoration, articulate at this time to establish visual assurance of what not to cover with GIC.

4) Air-dry tooth surfaces then condition for 10 seconds with polyacrylic acid ("tooth conditioner") then rinse and dry

5) Apply SDF to all carious enamel and dentin tooth surfaces with a microbrush, scrubbing for as long as a minute if time and behavior allow. Leave tooth surfaces SDF-moist. If too wet with SDF then gently dab with cotton or with a microbrush dabbed dry on the patient's napkin. Don't air dry because that can spread the SDF away from the lesion. **Never rinse with water after applying SDF**. Leaving SDF un-diluted inside the "caries sponge" is what maximizes the depth of silver and fluoride ion-penetration and assures that the SDF will be at full strength down to the base of the lesion.

6) Apply GIC or an RMGI to the SDF-damp lesion being careful to fill from the floor of the lesion up to avoid creating air bubbles. Condense using a water-moistened gloved finger for GIC or an unfilled resin-moistened finger for RMGI pressing apically and from side-to-side. Keep GIC moist with water or saliva; keep RMGI moist with a thin coat of unfilled resin. Pure GIC takes 2.5 minutes to set and RMGI is set in 20-40 seconds by light curing.

7) Manufacturer's recommendations often advise coating pure GIC with unfilled resin (like Fuji coat) but that needs to be light cured which will cause the

underlying SDF to oxidize thus turning the restoration black. If that is an issue on posterior teeth not in the smile line, you can skip coating or coat with unfilled resin and don't light cure or chose instead to coat with a thin layer of petroleum jelly. Actually, as long as the GIC is fully set (2.5 minutes) coating or covering is not important. RMGI must be light cured so those SMART restorations will always turn black however most of the black is only on the surface and will wear off rapidly leaving a grey or slightly brownish restoration that is as hard as glass.

8) If pure GIC is used, dismiss the patient with instruction to not eat or drink for an hour, favor eating on the other side and/or eat a soft diet for 48 hrs. If RMGI is used this is not an issue since that material is light cured to immediate hardness.

9) Ask patients to return 3 weeks later for more SDF+GIC or RMGI in/on the same lesion in the event that any GIC or RMGI is lost.

10) Prescribe 5,000 ppm fluoride-containing toothpaste. Extra topical fluoride can help insure better clinical results because SMART is all about re-mineralization, bacterial stasis and the constant re-charging of GIC and RMGI with fluoride from a dentifrice (*Arbabzadeh-Zavareh et al., 2012*).

Class II

Note: This protocol is the same whether applying SDF multiple times over multiple appointments before applying GIC or RMGI or if doing Same-Day SMART .

1) Whenever possible when doing Class II SMARTs, it is advisable to create an occlusal dovetail as an extension of the proximal box of the lesion. The dovetail should be cut conservatively if the patient can tolerate the use of a small 330 bur on a highspeed handpiece cutting less than 1mm into enamel only. A dovetail of this nature greatly helps to assure retention of the GIC or RMGI in Class II SMARTs (**Fig. 8)**

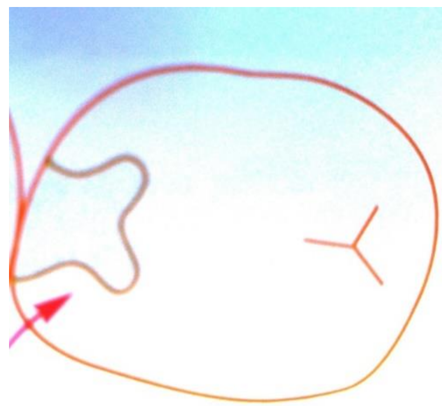


Figure 8.

2) If an interproximal lesion has not broken through the marginal ridge on a posterior tooth, a small, sharp 330 bur can be used only in enamel to "pop the top off" to gain access to the underlying lesion with a small spoon excavator and then with SDF and GIC or RMGI

3) "Shims", short pieces of stainless-steel matrix band material (Matrix Roll from Schein, 3/16" #100-1876, 10' for $8), can be cut for use between teeth as thin tooth separators to help maintain contact points when doing Class II SMART (**Figs 9,10,11).** It is not advisable to use wedges because SMART, by definition, is done without local anesthetic and wedges often cause discomfort. To avoid overhangs, slide shims out sideways in a controlled way by using a locking hemostat while

Figure 9: Shim in place ready for Class II SMART on #S (note GIC sealant on #T).

Figure 10: Applying SDF with shim in place before applying GIC.

Figure 11: GIC applied before removing shim sideways, not up.

maintaining contact of the shim with the rounded contour of the tooth's crown.

4) Floss can be used instead of shims by first using a standard "plastic instrument" to form marginal ridges. Then floss can be drawn through the contacts to create contact points instead of using shims or matrices. Just before the final self-set of a GIC before it skims over (or after one second of light curing a RMGI), draw the floss between teeth to create proper contact. When doing this, care must be taken to withdraw the floss sideway, not occlusally, to insure that the newly set material in the proximal box does not "lift out". Then let the GIC fully set (2.5 minutes) or light cure the RMGI for 20-40 seconds.

5) Never remove a matrix, shim or piece of floss occlusally, but instead, always remove to the side and a bit apically while closely following the crown's contour to avoid creating overhangs or dislodging of newly set GIC and RMGI.

Anterior Teeth:

Note: Ideally, we want to mask SDF scars.

Protocol if patient behavior is an issue:

1. Apply SDF 3X, at separate appointments to arrest caries

2. Once caries arrest is confirmed (**Fig 12**) etch it and surrounding virgin enamel with phosphoric acid

3. Rinse, dry

4. Apply low viscosity bonding agent and light cure for 10 seconds

5. Apply a high-resin-content RMGI "opaquer" (like Shofu Beautifil Opaquer) working it into and over the arrested caries with the needle applicator tip, then light cure. (**Fig 13).**

Figure 12: SDF was applied 3x on 2-year-old.

Figure 13: Light-cured high-resin-content RMGI opaquer used as a veneer masks the black scar. High-resin RMGI opaquers release zero fluoride; they simply mask the black SDF "scar". Such opaquers have no significant preventive effect, are not highly re-mineralizing and should be considered cosmetic only.

Protocol if patient behavior is not an issue:

1) Apply SDF at three separate appointments to arrest caries (**Fig 14).**

Figure 14: SDF-arrested and unexcavated decay.

2) Once caries arrest is confirmed, remove as much superficial black stain as possible with a spoon excavator

3) If full crown coverage is not indicated, apply GIC or RMGI and adapt to the facial surfaces with water (for GIC) or unfiled resin (for RMGI) as a lubricant on a gloved fingertip and/or on a flat bladed plastic instrument. Continue to control moisture with a saliva ejector, gauze or cotton rolls being sure to keep the glass moist but not saturated. Then let it set if GIC or light cure if RMGI (**Fig 15).**

Figure 15: RMGI applied over the SDF-arrested and unexcavated decay.

4) If full crown coverage is indicated, fit a strip crown (celluloid crown form), make two vent holes on the lingual surface of the crown form, condition tooth surfaces with PAA, load the crown form with an opaque GIC (like EQUIA Forte, Riva H) or an RMGI (like Fuji II LC), seat the crown, remove excess material from the vent holes, light-cure if using RMGI or wait 2.3 minutes for self-cure if GIC, remove the strip crown, trim and finish (**Fig 16).** If behavior becomes an issue, celluloid strip crowns can be left on and removed at a later appointment.

Figure 16: Strip crowns (photo courtesy of Thierry Boulanger, Brussels).

5) Trim and finish as necessary after the GIC is fully set or after light curing the RMGI.

Strip Crowns

Note: The SMART protocol for strip crowns follows the same general SMART caveats as above whether applying SDF multiple times over multiple appointments before applying GIC or RMGI or if doing Same-Day SMART where SDF is only applied once before applying GIC or RMGI at the same appointment.

1) Fit a strip crown (celluloid crown form).

2) Make two vent holes on the lingual surface of the crown form

3) Condition tooth surfaces with PAA

4) Load the crown form with an opaque GIC (like EQUIA Forte, Riva H) or an RMGI (like Fuji II LC).

5) Seat the crown, remove excess

Same day SMART strip crowns can sometimes have a dark shine-through feature. Dark SDF “shine through” under a SMART strip crown in a baby tooth may be concerning to some parents and may not be to others. Some parents are so relieved that the black arrested caries is somewhat masked by white GIC or RMGI that they simply do not care. However, when aesthetics is an issue, we can opt for multiple day SMART strip crowns then mask the black SDF scar with an RMGI opaquer (Shofu Beautifil Opaquer) before placing a strip crown filled with a RMGI or pure GIC for a perfectly white aesthetic result with zero dark shine-through. That requires applying SDF multiple times over multiple appointments before applying GIC or RMGI in a strip crown. That does not make one way or the other way (Same Day SMART or multi-appointment SMART strip crowns) right or wrong because the target outcome of arrested decay with reasonably acceptable baby tooth aesthetics is satisfied to varying degrees both ways. This situation only demonstrates that in different patient populations, in different clinical settings, in differing economic circumstances, SMART strip crowns (and SMART in general) can work across a very wide spectrum of patient and parental preferences and can be done over multiple appointments or can be done on the same day.

Materials, Instruments and Techniques for SMART:

Teamwork

For younger children, it is often advantageous to encourage parental assistance by using the lap-to-lap or knee-to-knee technique for SMART. The dentist sit's knee-to-knee with the parent or guardian, the patient's legs wrap around the parent's/guardian's waist, the patient's head is held upright on the dentist's knees and the parent/guardian holds the child's hands (see **Fig 17**).

Figure 17: Lap to lap treatment.

Some young children will cry at this point which is fine because their mouths will then be open and the teeth to be treated will be accessible. If a child chooses to close his/her mouth, the gentle use of a mouth prop like a Molt-type can be used as shown below.

Excavation without local anesthesia

Local anesthesia is not always necessary for SMART but removing mushy tooth material before providing SMART is always highly recommended. First isolate the lesion as best you can then, if possible, clean the circumference of the lesion with a spoon excavator and also if possible, make shallow retentive undercuts to help enhance initial retention of the GIC. Painless excavation around a lesion's circumference and/or creating retentive undercuts using hand instruments should never be done deeply. The patient is your "depth gauge": if the patient shows any signs of pain whatsoever, do not go deeper.

Isolation

There are many ways to isolate and whatever works for this purpose is acceptable. New isolating devices will continue to be invented in the future and those will be acceptable too. Some form of isolation is necessary for SMART because decayed enamel and/or dentin is "sponge-like" and the "decay sponge" must be dried of all saliva before applying SDF. Saliva is too ropy, too thick, and too molecularly large to be easily penetrated by silver ions. Therefore, isolate, pumice tooth surfaces, rinse, dry thoroughly, then apply SDF preferably for at least one minute. Isolation and dryness of the lesion are critical for SDF to work optimally and achieving dryness can be more challenging with patients who have copious salivary flow and less challenging with patient with naturally drier mouths.

Pumice vs. prophy paste to prepare tooth surfaces for glass-ionomer application

Before starting a SMART protocol or when applying glass ionomer sealants, it is advisable to pumice tooth surfaces first to remove pellicle and proteins. Prophy paste is not a good substitute for pumice because it contains flavoring and pigments that can interfere with GIC and RMGI chemistry.

How to properly activate GIC or RMGI capsules

Before activating a GIC or RMGI capsule, tap it sideways on a hard surface to "fluff" the powdered glass inside to assure greater consistency in GIC and RMGI mixtures then, from there, follow the manufacturer's recommendations before triturating. GIC and RMGI capsules contain powdered glass and polyacrylic acid (PAA) which are separated by a thin membrane inside each capsule of material. Final activation involves perforating that membrane with a click of a GIC activation gun before the capsule is placed in the triturator so the glass powder and the PAA liquid can be mixed together.

Consider using GIC and RMGI for sealants at the same time as doing SMART

When applying GIC or RMGI in a SMART protocol, clinicians should also consider applying glass-ionomer sealants on posterior primary and permanent molars during the same visit. This can help to assure greater full-mouth caries prevention especially in high-risk patients and it helps to use up glass material in capsules that would otherwise be wasted. The more SDF, GIC or RMGI that is applied in/on multiple teeth of high-risk patients, the more future caries can be prevented because GIC and RMGI act as mineral and anti-bacterial reservoirs within treated teeth as well as for adjacent teeth. When doing SMART, the glass-ionomer capsules loaded in the applicator gun are already on the treatment tray or in the clinician's hands. Thus, providing glass-ionomer sealants at a visit scheduled for SMARTs requires no extra material or time.

Polyacrylic acid (PAA) conditioning

GIC Inside each capsule of GIC and RMGI, contains un-pigmented clear PAA which is separated from the glass powder by a thin membrane. When capsules of glass-ionomer are activated in a dispensing gun, the membrane is broken and when capsules are triturated, the glass powder and the PAA liquid mix together, initiating a release of mineral ions that facilitate glass-to-tooth adhesion. The most important features of glass-ionomer chemistry are: 1) an acid-base reaction; 2) a mineral ion-exchange adhesion to tooth structure; and 3) the continued ionic mobility of fluoride, calcium and phosphate ions within the glass-ionomer even after the material sets. A water-based environment With GIC and PAA working together, make all three of these features possible. It cannot happen without water or without PAA.

Even before glass-ionomer is applied to a tooth, PAA (used as blue tinted "tooth conditioner") releases mineral ions on enamel and dentin surfaces which then become available to interact with complimentary mineral ions that are in the triturated glass material. Some have suggested that five seconds of etching with 38% phosphoric acid can be substituted for 10-20 seconds of PAA application. **This is not advisable** <u>because 38%</u>

phosphoric acid has a much lower pH than does 10-20% PAA and, after rinsing, phosphoric acid washes away the mineral ions on the tooth surfaces with which we want glass-ionomer to interact. Always follow manufacturer guidelines.

It's especially important in the "Same-Day SMART" protocol (when SDF and GIC or RMGI are applied simultaneously in one visit) to condition tooth surfaces with PAA for 10 seconds then rinse *before* applying SDF. If PAA is applied *after* SDF in Same-Day SMART, the rinsing of PAA conditioner off the tooth will dilute the underlying one-time SDF application decreasing the concentration of silver ions and the SDF's anti-bacterial and re-mineralizing potency. In situations other than Same-Day SMART, when SDF is applied several times over several visits before GIC or RMGI is applied, PAA conditioner can be applied and rinsed off before GIC or RMGI is applied with or without applying additional SDF.

> *"The paragraph above is very important, please make sure to read it multiple times."* - Dr. Steven Duffin

Is it ok to use RMGI vs. pure GIC for SMART?

The same *permanent acid -resistant zone of chemical fusion* at the glass-tooth interface is created with RMGI of 80% pure content as is created with 100% pure GIC (**Fig 18).**

Some clinicians prefer RMGI because it is a light-cured material. This can be beneficial for difficult-to-manage patients because light-curing is convenient and fast. Anyone using a glass-ionomer material that is curable by a light should understand that such a material is not pure GIC, it is RMGI. RMGI's light-sensitive capability resides in its resin content. For SMART, it's fine to use RMGI as long as the RMGI contains at least 80% pure GIC and no more than 20% resin. More than 20% resin in RMGI renders it potentially non-medicinal since there is nothing preventive, re-mineralizing, bioactive or healing about resin. In other words, the "healing" part of RMGI is in its pure GIC content.

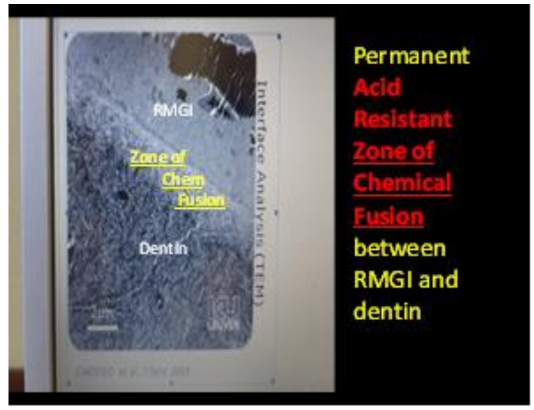


Figure 18: (Cardoso et al., 2010).

It's also important to understand that all RMGI is "dual-cure" (sets with and without a light). However, it is absolutely a MUST that RMGI be light cured as a finishing step. Otherwise un-polymerized resin in the RMGI's bulk will make it weak. A popular formulation of RMGI that contains 80% pure GIC is Fuji II LC. A newer material called Fuji Automix LC is basically Fuji II in a two- part paste that extrudes through a disposable mixing tip in a way that eliminates the need for capsules or triturators.

A popular formulation of pure GIC is Fuji IX. Recently, additional strontium and aluminum (which are also found *naturally* in teeth) were added to create Fuji EQUIA Forte. All of these materials work well for SMART and are mentioned here because it is obvious that major glass-ionomer manufacturers are entering the market with newer and better products with improved properties.

Both GIC and RMGI (that contain at least 80% pure GIC) release more fluoride than any other restorative material used in dentistry today, including those purported to be “bioactive” but which are often just resin. Resin is inert and anhydrous, thus cannot participate in any tooth-healing mineral-ion exchange which requires water. Mineral ions cannot transfer from GIC or RMGI to teeth through air. Glass-ionomer does not work without water (moist surfaces) during and after application.

In terms of the aesthetics of a final Same-Day SMART restoration, it’s important to note that there are differences between GIC and RMGI. Light-curing draws underlying SDF into overlying RMGI which turns a final SMART restoration dark (**Fig19**). Pure GIC used in SMART ends up whiter (**Fig20**) because pure GIC does not require light-curing thus there is no immediate oxidation of underlying SDF. For SMART restorations done on posterior teeth that are not in the smile line, many clinicians feel that the darker final result of RMGI used in Same-Day SMART is acceptable since it is no darker and is often lighter than an amalgam restoration. Regardless of color, clinical outcomes demonstrate that light cured RMGI and self-cured pure GIC seem equally effective in SMART relative to de-sensitizing, anti-microbial and re-mineralizing actions.

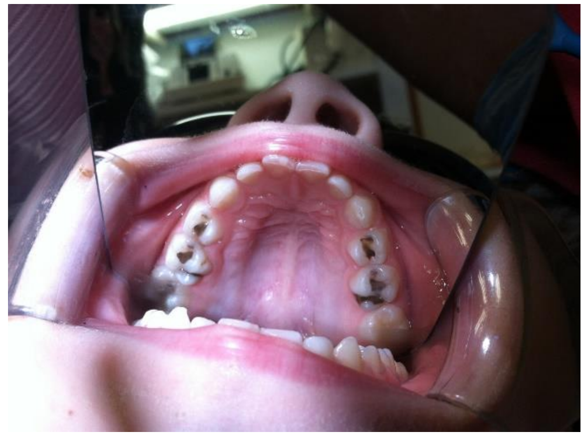


Figure 19: A one-year post-op image of SMARTs done with light-cured RMGI in an upper arch.

Figure 20: A one-year post-op image of SMARTs done with self-setting GIC in an upper arch.

Moisture control when doing SMART

When using GIC and RMGI capsules in the SMART protocol, the material is best applied by placing the capsule tip in the bottom of the lesion then slowly lifting the capsule in an occlusal direction as the glass material is expressed from the applicator gun. This greatly helps to avoid any air bubbles. Then, with pure GIC, the use of a gloved finger lubricated with a very small amount of saliva or water while pushing the material apically and side-to-side helps to avoid high spots in occlusion and facilitates condensation of material. When using RMGI, the use of a gloved finger lubricated with unfilled resin (like Fuji Coat LC, Fuji varnish or G-

Coat Plus) works well when combined with light-curing the coating and the RMGI simultaneously after adjusting for occlusion before the material is set. If concerned about creating high spots when employing these techniques, thin articulating paper can be used before applying glass-ionomer so that all articulated high spots can be cleared with finger pressure or plastic instruments before the material self-sets or is light cured.

It is of prime importance to apply GIC or RMGI to moist tooth surfaces. Surfaces should not be too wet or too dry. When doing “Same-Day SMART” the moisture needed for proper glass chemistry is provided by the 62% water content of the applied 38% SDF. If GIC or RMGI become too dry while setting, they begin to look chalky and cracked. Allowing that to happen will invariably lead to fracture and failure. If GIC or RMGI become overly saturated with water and/or saliva while setting, they can wash away from tooth surfaces, or can absorb too much water while setting which is just as bad as letting them get too dry. During the self-setting phase of GIC (2.5 minutes), the outer surface of the material should be kept slightly moist with water or the patient’s saliva. During the light curing phase of RMGI the outer surfaces should be kept moist with unfilled resin (like Fuji Coat). These measures assure that the water content of the glass material remains stable during setting.

Do not disturb surfaces of glass-ionomers as they are setting: When GIC or RMGI begins to visually gel, this represents a sign that it is beginning its initial set phase. During this period, it is extremely important not to disrupt any glass-ionomer! If more finishing is necessary, it must be done later after the material is fully set. **Do NOT have patient close to check bite during this phase.** Either do so prior to the gel set phase of the GIC, or adjust the bite after set with rotary instruments.

Ideal SMART vs. non-ideal SMART

Ideal SMART is often appropriate for well behaved, compliant patients treated where modern dental technology is available. Non-Ideal SMART is more appropriate in situations when patients are not compliant and/or for Same-Day SMART when patients will only be seen once with no opportunity for follow-up treatments and/or when clinicians are working without electricity or running water. Theoretically, we would expect to see better outcomes when doing Ideal SMART vs. Non-ideal SMART. However, that has not yet been proven and clinical outcomes suggest that they have similar or equal outcomes.

Ideal SMART is possible 1) when the teeth can be pumiced beforehand and 2) when the perimeter of the lesion(s) can be cleaned with hand instruments or with a bur down to solid tooth structure (but never over the pulp) and 3) when PAA tooth conditioner can be applied for 10-20 seconds then rinsed. The reason to do these 3 steps when possible is that there is increasing scientific evidence that these measures generally create a better seal between glass-ionomers and teeth. Regardless, one should not be deterred from providing Non-Ideal SMART when necessary, since many clinicians have reported positive outcomes even when unable to ideally perform the 3 steps mentioned. Non-Ideal SMART is always better for high-risk patients than no SMART at all, if clinical conditions cannot be controlled, when facing rampant caries lesions in patients who are phobic, non-compliant, itinerant or when clinicians are unable to schedule multiple follow up visits, or when the perimeter of lesions cannot be cleaned.

How and why SMART can lead to better oral health in high risk of caries populations:

1) SMART is non-threatening, non-invasive, and non-traumatic. Thus it is well accepted by frightened children. Only 50% of all children with paid-for benefits via Medicaid and private insurance utilize the benefits they already have. The reasons cited are too expensive, too invasive, and bad previous dental experiences (*Kaiser Family Foundation, 2016*). SMART fixes that.

2) Bacterial diseases of the human body, including dental caries, cannot be treated effectively by surgical means alone. Surgical management as a stand-alone treatment option is contraindicated when the treatment goal - before any other goal - is the establishment of a measurable reduction in the disease.

3) SMART simultaneously treats and controls the disease itself in a minimally invasive way.

4) SDF and GIC used in SMART are anti-microbial and appear clinically to have a positive, effect on oral biofilm. SDF and GIC have both been proven to slow down bacterial destruction generating from oral biofilm when they are used separately.

5) Only applying antimicrobial liquids (like SN, AgF) does not address cavitation. Open, cavitation, even when caries is arrested, can still trap substrate and can lead to food impaction between teeth, a situation often miss-interpreted by patients as a toothache. SMART addresses cavitation in a way that restores function in helping to prevent food impaction into areas where decay has broken thru between two teeth. And may lead to food impaction.

6) In the Medicaid population, especially an affordable, safe, non-traumatic technique without needles and drills is needed for arresting caries in as many teeth as possible in one appointment while simultaneously desensitizing pain and filling cavitations in a way that helps to prevent future caries lesions. SMART does exactly that.

7) General anesthesia used to treat children for dental needs is not 100% safe and in-office sedation with an anesthesiologist offers a false sense of security. SMART helps to avoid the need for sedation and general anesthesia especially because phobic children are more manageable in the dental chair when they're told that they will not need shots or drills.

A striking example of how SMART changed dental health in a remote Alaska village:

Flying to a remote Alaskan barrier island.

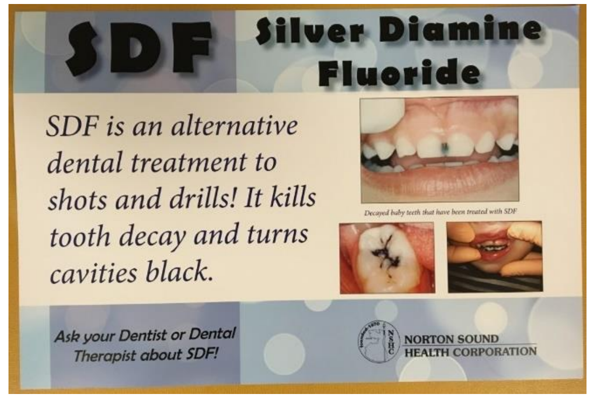
With 3 dentists and this product for cargo. Before SMART, thirty kids a year were flown out to an Anchorage hospital for operating room dentistry under general anesthesia.

Teaching Alaska dentists to do SMART in a remote clinic in a native village.

After SMART, Only 2 children a year (vs. 30) were flown from the village to Anchorage for hospital dentistry.

Is SMART a potentially higher standard of care?

It's been shown that caries relapse following operating room gold-standard dentistry is between 22% and 79%" (*Twetman & Dhar, 2015*). Thus, when kids are put to sleep for



The poster that the Alaska dentists made for their patients in the village.

conventional drilling and filling in a situation where there are no distractions, we can expect to see post- operative recurrent decay as often as 79% of the time. When we couple that with evidence to prove that GIC has a highly effective calcifying effect on de-mineralized enamel and dentin (*Ngo, Mount, Mc Intyre, Tuisuva, & Von Doussa, 2006*) and that SDF is highly anti-bacterial, we can argue that there is strong reason to further explore the combination of SDF and GIC to help supplant the need for expensive and life-threatening hospital dentistry (which often costs between $5K and $10K per case), especially for Medicaid patients whose hospital dentistry is ultimately paid for by taxpayers.

No restoration is "permanent" or "definitive":

Anything and everything that anyone ever put in/on a tooth with the intention of providing a permanent "seal" can, and usually does, eventually leak. When that happens with resin restorations, resin sealants, and other types of conventional restorations, we often see recurrent decay. On the other hand, when a GIC or RMGI restoration or sealant leaks we don't often see recurrent decay due to the high fluoride release from the glass-ionomer (i.e. Fuji IX). Pure GIC releases 20ppm of F in the 1st month, 10ppm at 1-2 months, 5ppm at 2-8 months and 2.5ppm from 8-12 months according to TRAC Research data from Dr. Rella Christensen).

RMGI that contains 80% pure GIC also releases a lot of fluoride. Resins release almost zero fluoride. Amalgams release silver ions and thus, under many old crumbling amalgams, we often find black, arrested decay, but no re-mineralization because amalgams release no fluoride.

When GIC is lost from a SMART, it is not an indication of failure.

Even when GI appears to a clinician's naked eye to be "lost", islands of GIC or RMGI remain that continue to act as a fluoride reservoir for all teeth in a patient's mouth**.** Furthermore, GIC and RMGI create a *permanent acid-resistant zone of chemical fusion at the tooth surface* whether the GIC is evaluated by the naked eye as being "retained" or not (*Mount, 2002*).

Caries excavation

Some clinicians prefer not to excavate at all when doing SMART but it has been the anecdotal experience of many and the peer reviewed evidence from the founder of the ART concept, Dr. Jo Frencken, that outcomes are better when mushy de-mineralized tooth material can be removed before applying GIC (*Frencken, Pilot, Songpaisan, & Phantumvanit, 1996*). Outcomes are also better when the margins of lesions to be treated with glass-ionomer cements can be cleaned. "Clean" can have several connotations, especially when considering patient cooperation. It is ideal (but not always possible) to remove caries at the lesion's perimeter with a spoon excavator (down to sound tooth structure). This step greatly enhances the ability to create a chemical bond/seal so that an uncontaminated internal re-mineralized tooth layer can eventually develop under glass-ionomer cement. Re-mineralization is best achieved when we can clean the perimeter as well as possible without inflicting pain. Generally, it always helps the eventual formation of a glass-ionomer seal to first remove superficial food/bacteria/infected dentin and as much protein as possible without approaching the pulp and without inflicting pain (*Mount, 2002*). If it is not possible to clean the perimeter or to remove superficial substrate, one can apply SDF and GIC or RMGI anyway with the anticipation that it may be necessary to eventually re-apply both again. Reapplication is simple, does not traumatize and eventually can arrest caries and re-mineralize tooth structure over time even when cleaning the perimeter of the lesion or removing superficial substrate is impossible.

Creating shallow undercuts to enhance initial GIC retention

Small, shallow retentive undercuts can be made around the enamel of occlusal lesions, and made with an occlusal dovetail on the occlusal surfaces of Class II lesions, but are done only if necessary to assure initial retention of GIC and RMGI used in SMART. Occlusal and proximal retention in Class II lesions can be done with a spoon excavator or a small round bur, quickly and without local anesthesia. No attempt should be made to scrape or drill deeply. The goal is not to excavate leathery decayed dentin, only to create very slight mechanical retention.

Final finishing and coating of a Freshly placed SMART

After its initial set, pure GIC has a relatively soft surface (especially when compared to a freshly placed, light cured RMGI). Pure GIC requires almost 48 hours before it achieves adequate compressive strength and takes almost 8 weeks to achieve full final strength. Because of the initial soft surface of a pure GIC SMART restoration, finishing can be a problem. After initial placement and curing, it is best to allow the material to rest undisturbed for a few minutes. After that, non-aggressive finishing and polishing instruments like pointed tapered burs, or fine or extra-fine finishing disks can be safe to use.

To coat or not to coat Glass-ionomer as a final step**:** Some clinicians like to coat their GIC's and RMGIs with clear unfilled resin to temporarily protect them from water loss and/or water absorption over a 24-48-hour period. Unfilled resin coating (like Fuji Coat) applied to the surfaces of GIC products need to be light cured.

This polymerization step helps to make the outer surface of the GIC smooth, especially if final finishing with burs or disks is necessary. Unfilled resin coatings can also be useful when moisture control for the first 2.5 minutes of setting is a challenge. In situations where moisture on the setting glass-ionomer surface is difficult to control, coat with anything from a light layer of petroleum jelly to a low viscosity unfilled resin bonding agent both of which will eventually wear off.

Ideally, as soon as possible after initial setting, we want GIC and RMGI to be influenced positively by the patient's saliva so calcium and phosphate ions can be drawn immediately into the outer glass surface. This ion-exchange between the tooth, glass and saliva helps to molecularly link the glass to teeth. Plus, we want glass-ionomers to be able to deliver fluoride from our SMART restorations to adjacent teeth without any outer shielding of the material.

How should we code SMART?

1. If a clinician is confident in his/her ability to provide SMART in a way that satisfies the metric of visually confirmed retention, then SMART can be coded as a "composite" because SDF+GIC is a "composition" of dental materials. (The CDT book has *finally* identified GIC itself as a "composite material" making that aspect of coding for SMART legal.)

2. If one is new to this and feels like they may need to re-apply SDF+GIC repeatedly because they have not yet learned all the tricks that make GIC retain over SDF-dampened caries, then they can code SMART as an ITR or as a Sed Fill which, although covered at a lower rate, can usually (in most states) be charged as many times as it is necessary to replace them. When one charges SMART as a "composite per surface" it is covered at a higher rate but in most states, SMART coded as a composite per surface is allowed to be charged once only. Please confirm with your local coding practices.

3. For those dentists who wish to have their RDHs place SMARTs with either direct or indirect supervision (depending upon the language in their state's dental practice act) the RDH or the dentist should then code SMARTS as ITRs or Sed Fills.

SMART is a paradigm shift. Between the paradigms, we have chaos. Five years from now we'll all be laughing at how we had to be "creative" in the "early days" just to keep our doors open to treat patients with SMART. Regardless, no matter how we bill we must be sure that we can justify why we bill the way we do. We must be able to understand the microbiology, the cariology, and the materials that we use in patient care.

When To provide SMART vs. a more traditional restoration?

SMART treats the disease FIRST and the symptoms of the disease when time, money and behavior allow. Thus, when a patient presents with many lesions, we can treat every one of those lesions immediately, non-traumatically in one appointment. This arrests the disease. It does not completely stop the disease nor is it a panacea. It simply puts the disease in "jail' so it can't grow, spread or progress as quickly as it would if one tooth at a time were to be restored conventionally. Then, when the disease is under control, dentists can discuss with patients what is further indicated. SMART on all caries lesions buys dentists and patients time without allowing the disease to advance as quickly because SMART "puts the fire out" especially for patients with high risk of caries. SMART fillings can be replaced with conventional restorations at any time later and they can be refined or have SDF and GIC added at any time.

In conclusion

Intact, asymptomatic SMART restorations need a few years without removal for clinicians to see radiographic evidence of the formation of secondary dentin over the pulp. When we remove and replace a SMART restoration with a "conventional" restoration like a composite, the patient often has to undergo a drilling procedure that can continually weaken teeth. In some situations, as with high caries risk patients, in patient who simply can't pay for conventional restorations, in patients with fear of needles and drills, in decayed primary teeth that will soon exfoliate, SMART restorations refined at frequent recall appointments may be the best treatment of choice. Some patients just want minimal invasion and anti-bacterial management and when we offer them more invasive approaches to care, they simply quit going to the dentist. SMART can be a tool to help such patients whether or not they chose to have anything more than SMART and refined SMART restorations. It's also very probable that newer, better antimicrobial agents, and glass-ionomers will soon be introduced into the dental marketplace, and that dentists may eventually be able to create "super teeth" from decayed teeth by treating caries non-traumatically with even better anti-microbial agents and re-mineralizing agents that are applied with minimal surgical invasion over time.

References

Arbabzadeh-Zavareh, F., Meyers, I., Mortazavi, S., Gibbs, T., Bouzari, M., & Walsh, L. (2012). Recharge pattern of contemporary glass ionomer restoratives. Dental Research Journal, 9(2), 139. https://doi.org/10.4103/1735-3327.95226

Barja-Fidalgo, F., Maroun, S., & de Oliveira, B. H. (2009). Effectiveness of a Glass Ionomer Cement Used as a Pit and Fissure Sealant in Recently Erupted Permanent First Molars. Journal of Dentistry for Children, 76(1), 34-40(7).

Beiruti, N., Frencken, J. E., van't Hof, M. A., Taifour, D., & van Palenstein Helderman, W. H. (2005). Caries-Preventive Effect of a One-Time Application of Composite Resin and Glass Ionomer Sealants after 5 Years. Caries Research, 40(1), 52–59. https://doi.org/10.1159/000088907

Berg, J. H. (2002). Glass ionomer cements. Pediatric Dentistry, 24(5), 430–438.

Cagetti, M. G., Carta, G., Cocco, F., Sale, S., Congiu, G., Mura, A., … Strohmenger, L. (2014). Effect of Fluoridated Sealants on Adjacent Tooth Surfaces. Journal of Dental Research, 93(7_suppl), 59S-65S. https://doi.org/10.1177/0022034514535808

Cardoso, M. V., Delmé, K. I. M., Mine, A., Neves, A. de A., Coutinho, E., De Moor, R. J. G., & Van Meerbeek, B. (2010). Towards a better understanding of the adhesion mechanism of resin-modified glass-ionomers by bonding to differently prepared dentin. Journal of Dentistry, 38(11), 921–929. https://doi.org/10.1016/j.jdent.2010.08.009

Chibinski, A. C., Reis, A., Kreich, E. M., Tanaka, J. L., & Wambier, D. S. (2013). Evaluation of primary carious dentin after cavity sealing in deep lesions: a 10 to 30-month follow-up. Pediatric Dentistry, 35(3), E107–E112.

Craig, G., & Powell, K. (2013). A handbook of expanded atraumatic techniques for the apprehensive child dental patient. Camperdown, Nsw: Dental Outlook Publications Pty Ltd.

Dye, B. A., Mitnik, G. L., Iafolla, T. J., & Vargas, C. M. (2017). Trends in dental caries in children and adolescents according to poverty status in the United States from 1999 through 2004 and from 2011 through 2014. The Journal of the American Dental Association, 148(8), 550-565.e7. https://doi.org/10.1016/j.adaj.2017.04.013

Featherstone, J. D. B. (2000). The Science and Practice of Caries Prevention. The Journal of the American Dental Association, 131(7), 887–899. https://doi.org/10.14219/jada.archive.2000.0307

Featherstone, John. (2003). The caries balance: contributing factors and early detection. Journal of the California Dental Association. 31. 129-33.

Frencken, J. E., Pilot, T., Songpaisan, Y., & Phantumvanit, P. (1996). Atraumatic Restorative Treatment (ART): Rationale, Technique, and Development. Journal of Public Health Dentistry, 56(3), 135–140. https://doi.org/10.1111/j.1752-7325.1996.tb02423.x

Hicks, J., Gargia-Godoy, F., Donly, K., & Flaitz, C. (Eds.). (2003). Fluoride releasing restorative materials and secondary caries. Journal of California Dental Association, 31(3), 229–245.

Horst, J. A., Ellenikiotis, H., & Milgrom, P. L. (2016). UCSF Protocol for Caries Arrest Using Silver Diamine Fluoride: Rationale, Indications and Consent. Journal of the California Dental Association, 44(1), 16–28. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4778976/

Huang, Wei-Te & Shahid, Saroash & Anderson, Paul. (2019). Silver Ions Accelerate Rate of Enamel Demineralization. An In Vitro Dose-Response SMR Study of SDF. 10.1159/000499894.

Kaiser Family Foundation (2016). Kaiser Family Foundation Analysis of Medicaid Current Beneficiary: National Health and Nutrition Survey 2013-2016. Kaiser Family Foundation.

Mei, M., Li, Q., Chu, C.-H., Lo, E. C.-M., & Samaranayake, L. (2013). Antibacterial effects of silver diamine fluoride on multi-species cariogenic biofilm on caries. Annals of Clinical Microbiology and Antimicrobials, 12(1), 4. https://doi.org/10.1186/1476-0711-12-4

Mellberg, J. R. (1988). Remineralization: A status report for the American Journal of Dentistry, Part 1. American Journal of Dentistry, 1(1), 39–43.

Mickenautsch, S., Yengopal, V., Leal, S. C., Oliveira, L. B., Bezerra, A. C., & Bonecker, M. (2009). Absence of carious lesions at margins of glass ionomer restorations: a meta-analysis. European Journal of Pediatric Dentistry, 10(1), 41–46.

Milicich, G. (2005). A resin impression SEM technique for examining the glass-ionomer cement chemical fusion zone. Journal of Microscopy, 217(1), 44-48.

Milsom, K. M., Blinkhorn, A. S., & Tickle, M. (2008). The incidence of dental caries in the primary molar teeth of young children receiving National Health Service funded dental care in practices in the North West of England. British Dental Journal, 205(7), E14–E14. https://doi.org/10.1038/sj.bdj.2008.582

Mount, G. J. (2002). An atlas of glass-ionomer cements : a clinician's guide (p. Chapter 2). London: Martin Dunitz.

Mount, G. J. (2005). Defining, Classifying, and Placing Incipient Caries Lesions in Perspective. Dental Clinics of North America, 49(4), 701–723. https://doi.org/10.1016/j.cden.2005.05.012

Ngo, H. C., Mount, G., Mc Intyre, J., Tuisuva, J., & Von Doussa, R. J. (2006). Chemical exchange between glass-ionomer restorations and residual carious dentine in permanent molars: An in vivo study. Journal of Dentistry, 34(8), 608–613. https://doi.org/10.1016/j.jdent.2005.12.012

Ngo, H., Mount, G. J., & Peters, M. C. (1997). A study of glass-ionomer cement and its interface with enamel and dentin using a low-temperature, high-resolution scanning electron microscopic technique. Quintessence International, 28(1), 63–69.

Peumans, M., Kanumilli, P., Demunck, J., Vanlanduyt, K., Lambrechts, P., & Vanmeerbeek, B. (2005). Clinical effectiveness of contemporary adhesives: A systematic review of current clinical trials. Dental Materials, 21(9), 864–881. https://doi.org/10.1016/j.dental.2005.02.003

Pitts, N. (2013). Summary of: Treatment of early caries lesions using biomimetic self-assembling peptides – a clinical safety trial. British Dental Journal, 215(4), 174–175. https://doi.org/10.1038/sj.bdj.2013.811

Ricketts, DNJ, Kidd, E., Innes, N., Clarkson, J., & AM, D. G. J. M. (2007). Complete or ultraconservative removal of decayed tissue in unfilled teeth. Australian Dental Journal, 52(3), 252–253. https://doi.org/10.1111/j.1834-7819.2007.tb00497.x

Rosenblatt, A., Stamford, T. C. M., & Niederman, R. (2009). Silver Diamine Fluoride: A Caries "Silver-Fluoride Bullet." Journal of Dental Research, 88(2), 116–125. https://doi.org/10.1177/0022034508329406

Shah, N., Gupta, A., Sinha, N., & Logani, A. (2011). Remineralizing efficacy of silver diamine fluoride and glass ionomer type VII for their proposed use as indirect pulp capping materials - Part II (A clinical study). Journal of Conservative Dentistry, 14(3), 233. https://doi.org/10.4103/0972-0707.85796

ten Cate, J. M. (2013). Contemporary perspective on the use of fluoride products in caries prevention. British Dental Journal, 214(4), 161–167. https://doi.org/10.1038/sj.bdj.2013.162

Twetman, Svante & Vineet, Dhar (2015). Evidence of Effectiveness of Current Therapies to Prevent and Treat Early Childhood Caries. Pediatric dentistry, 37, 246-253.

Van Duinen, R. N., Davidson, C. L., De Gee, A. J., & Feilzer, A. J. (2004). In situ transformation of glass-ionomer into an enamel-like material. American Journal of Dentistry, 17(4), 223–227.

van Thompson, T., Craig, R. G., Curro, F. A., Green, W. S., & Ship, J. A. (2008). Treatment of deep carious lesions by complete excavation or partial removal. The Journal of the American Dental Association, 139(6), 705–712. https://doi.org/10.14219/jada.archive.2008.0252

WHO Collaboration, Center for Oral Health Services Research (1998). Groningen, The Netherlands.

Yamagishi, K., Onuma, K., Suzuki, T., Okada, F., Tagami, J., Otsuki, M., & Senawangse, P. (2005). A synthetic enamel for rapid tooth repair. Nature, 433(7028), 819–819. https://doi.org/10.1038/433819a

Hall Crowns

(Dr. John Frachella, DMD)

The Hall crown technique is a conservative, minimally invasive treatment for carious primary molars. It was developed in the 1980s by Dr. Norna Hall, a dentist working in Scotland. It involves cementing preformed stainless-steel crowns (SSCs) with glass ionomer cement (GIC) over carious primary molars without the use of local anesthetic, with partial or no caries excavation and with no surgical tooth preparation of any kind.

The Hall crown technique offers a non-surgical option to the classic surgical pre-formed SSC technique. For some time the Hall crown technique was controversial however there are now 5 randomized control trials showing Hall to be superior to other methods of managing decay in primary teeth (*Innes et al., 2017*). Generally, Hall crowns have better long-term outcomes with less pain and infection and with less need for replacement compared with standard fillings (*Innes, Ricketts, & Evans, 2007*) (*Gilchrist et al., 2011*). In one study, Hall was shown to provide a 97% success rate (*Ludwig, Fontana, Vinson, Platt, & Dean, 2014*). It has also been reported that Hall crowns are preferred by children, parents and dentists over traditional filling techniques that require using needles and drills (*Innes et al., 2017*). In short, the Hall technique provides dentists with a simpler, more effective treatment that can be delivered quickly in a way that limits patient anxiety and that saves primary teeth better than any other filling or crown technique known in dentistry. Needles, drills, sedation and general anesthesia are not needed. The only contraindication for doing Hall is when there are clinical signs and symptoms of irreversible pulpitis or of a dental abscess.

Review of Each Component of Hall Crowns

SSC's

Many studies have shown that pre-formed SSCs far outperform other methods of restoring primary teeth. Generally speaking, SSCs are considered favorable restorations for two-surface and larger carious lesions on primary teeth (*Innes et al., 2017*) (*Seale, 2002*) (*Randall, Vrijhoef, & Wilson, 2000*).

Partial caries excavation:

Systematic reviews clearly show the benefits of leaving caries partially or fully unexcavated in symptomless, vital decayed teeth (*Ricketts, Lamont, Innes, Kidd, & Clarkson, 2019*). Evidence summarized in a systematic review in 2013 found that incomplete caries removal can generally be more advantageous than complete excavation (*Schwendicke, Dörfer, & Paris, 2013*). Other studies show that simply sealing over unexcavated caries results in clinical and radiographic signs of caries arrest with the added advantage of promoting tertiary dentin formation. Many studies support minimal invasion of the pulp because it only makes sense to absolutely avoid invading viable pulps under any circumstances.

Glass ionomer cement

Glass ionomer cement (GIC), the "medicine inside" Hall, has been found to be 93% successful four years post-operatively when placed directly over unexcavated caries (*Marchi, de Araujo, Fröner, Straffon, & Nör, 2006*). When used for indirect pulp capping in primary and permanent molars, resin modified glass ionomer (RMGI) (which incidentally can be used in Hall instead of using pure GIC) was found to be 96% successful three years post-operatively (*Gruythuysen, van Strijp, & Wu, 2010*).

If We Modify Hall by First Adding Silver Ions, Could it be Even More Effective?

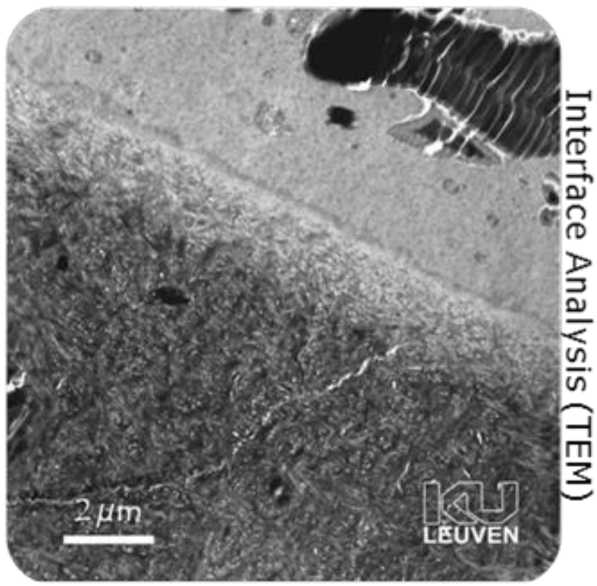
The question arises whether Hall, 40 years after it was first introduced, should remain unchanged forever or can Hall be improved by applying SDF to unexcavated caries prior to GIC or RMGI cementation of a Hall crown? Common sense tells us that preceding Hall crown cementation with an SDF application could provide additional lesion disinfection as well as more re-mineralization. On those grounds, combining Hall and SDF is very likely to be more effective than either SDF or Hall used alone. The rationale for suggesting this combination is that the application of silver ions advocates for additional disinfection of decay and additional stimulation of lesion re-mineralization (*Horst & Heima, 2019*). Also, silver ions, GIC and teeth are all water-based and synergistically bio-compatible (*Craig & Powell, 2013*). Glass ionomer chemistry is enhanced by adequate moisture on tooth surfaces aiding in the permanent adhesion of GIC and RMGI to metals like stainless steel (*Mount, 2002*) and SDF is 62% water.

When applying SDF before Hall, lesions and tooth surfaces can be moistened with SDF which has plenty of water in it to satisfy the requirement of proper GIC chemical adhesion to teeth. The seal under a SMART Hall crown is a complete, total and permanent barrier over unexcavated decay as well as over solid tooth structure. Caries cannot continue growing under this seal because air and decay-supporting substrates are cut off from contact by the permanent seal created by the GIC under an SSC.

Discussion of Materials and Protocols for Hall and Silver-Modified (SM) Hall

It is important to use proper materials for Hall crowns to be successful. Most pure GICs are of too high viscosity and they set too fast (2.5 minutes on average) for Hall crown cementation by operators of varying experience levels. Self-curing RMGIs (like GC Fuji PLUS and GC Fuji ORTHO, or GC Fuji VII EP**)** often work better because they have a lower film thicknesses and a 4-minute setting time. When using RMGIs for Hall crown cementation, it's best to choose those with a pure GIC content of no less than 80% because it's the glass itself that's anti-microbial and re-mineralizing, not the resin in the RMGI. With RMGIs of the proper ratio of 80 parts pure glass to 20 parts resin, the resin component provides a thinner film thickness which prevents fewer voids under SSC's as well as providing longer setting times. One RMGI (Fuji VII EP) contains CPP-ACP which is known to significantly reduce *S. mutans* biofilm (*Dashper et al., 2016*). Just like pure GIC, all RMGI should be applied directly onto moist tooth surfaces which secondarily eliminates the need for dry field isolation of teeth being treated, a distinct advantage for using the Hall crown technique in general.

It is significant to note that, as seen in the SEM micrograph below, an acid-resistant zone of chemical fusion develops between RMGI and dentin, the same way it does with pure GIC. In the image below, the lower portion is dentin and the top portion is RMGI. Between the two layers is a *permanent* acid-resistant zone that protects the dentin from recurrent de-mineralization and decay. This is true even when RMGI is lost from restorations that are placed without the coverage of a crown. It is important to understand that this in-between acid-resistant zone is *permanently* molecularly cross-linked to dentin.



CARDOSO et al. J Dent 2010

(Cardoso et al., 2010).

Which RMGIs are Best to Use for Hall Crown Cementation?

Some RMGIs are tinted blue (like GC Fuji Ortho) or pink (like GC Fuji VII EP) which can make it easier for clinicians and assistants or hygienists when removing excess cement after a Hall crown is placed and before the cement self-sets. All RMGIs are "dual-cure" (both self-setting and light curable) but, when RMGIs are used alone as a restorative material they must always be set with a curing light otherwise unpolymerized resin in the RMGI will weaken final restorations. This weakening of unpolymerized resins in RMGIs does not apply to RMGIs used under SSCs because lights can't cure under SSCs and because unpolymerized resin in self-setting RMGI used to cement an SSC does not weaken SSCs. The inherent strength of the SSC itself overrides any decreased cement strength. In that sense, RMGI used for cementation of a Hall Crown is medicinal and adhesive to the tooth, adhesive to the SSC and of adequate strength underneath the crown.

RMGI dispensed from a triturated capsule should be injected with the nozzle of the capsule placed deeply inside the crown so the glass-ionomer material can be expressed from the bottom of the SSC upwards, thus preventing the creation of voids and to <u>completely fill the crown</u> which assures full RMGI coverage over the tooth. Removal of excess RMGI during and after final crown-seating is best accomplished by first wiping off any un-set glass-ionomer with water-moistened 2X2 gauze squares opened and wrapped around an index finger and employed in a wiping motion before the cement "skins over". Then, an explorer or sickle scaler can be used to remove any cement that the wiping may have missed and/or to remove any excess cement that may have lodged interproximally. After seating a Hall crown, immediate flossing should be done carefully. Floss should be pulled out to the side, not occlusally to avoid unseating the crown as the RMGI is setting.

How to Create Space Between Teeth for Hall Crowns to Fit Without Drilling:

Hall and SMART Hall crowns, although not traumatic, are not always easy to seat. First, there must be sufficient space between teeth for Hall crowns to fit since Hall is best done without removing interproximal tooth structure. Also, Hall crown placement can become more challenging when placing side-by-side Hall crowns. This is especially problematic when faced with crowded posterior teeth and/or tight contact points. In crowded arches where interproximal spacing is non-existent, it may be

Figure 1.

necessary to first insert small rubber band orthodontic tooth separators left in place for 3-5 days in order to seat multiple (or sometimes even single tooth) Hall crowns (Figure 1)

In ideal clinical settings, tooth separators can be left in place for 3-5 days, however in situations where follow-up appointments may not be possible, sufficient space can sometimes be created with separators that are left in place for only 30-45 minutes. In some settings when children are not frightened by the sound of a dental drill, proximal space can be created by using a special, thin and pointed diamond called an IPR bur or interproximal reduction (IPR) bur on a highspeed handpiece with water.

Bite Opening with Hall Crowns:

Another issue of concern with Hall and SMART Hall crowns involves inevitable post-op bite-opening. Since it is not indicated in the Hall technique to surgically reduce tooth surfaces (even on occlusal surfaces) the bite is almost always opened postoperatively by about 2mm or more. Fortunately, Mother Nature corrects this situation spontaneously. Usually it only takes 3-4 weeks (and often less time) for other teeth in the arches (not treated with Hall) to supra-erupt and for a child's bite to self-equilibrate after Hall crowns are placed. Parents should be made aware that cutting food into smaller pieces and/or eating a softer diet may be necessary immediately after Hall and SMART Hall cementation.

Requirements for Providing Successful Hall and SM Hall Crown Treatment

1) One must understand and have confidence in the anti-microbial disinfection and re-mineralization potentials of SDF and glass-ionomer sealed under a SSC.

2) One must be open to employing methods of creating space surgically and/or non-surgically between teeth for the successful non-traumatic seating and cementation of Hall or SM Hall crowns especially when they are to be seated side-by-side on multiple teeth.

3) One must have a willingness to inform and educate parents and patients about the temporary opening of the bite when Hall and SM Hall crowns are provided.

A Final, Clear Definition of Silver Modified (SM) Hall

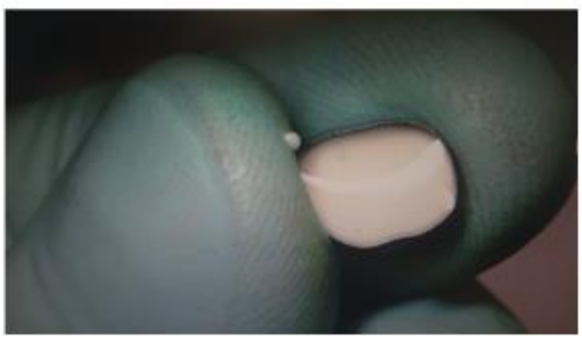
"SM Hall is a highly anti-bacterial, highly re-mineralizing and entirely child-friendly tooth-sealing technique using SDF combined with SSCs cemented with glass-ionomer, which open the bite temporarily in a way that spontaneously self-corrects in a few days or weeks."

Examples of Conventional Hall Crowns:

Hall = no needles, no drills

Courtesy Dr. Thierry Boulanger, Brussels.

Gently fit, then cement crown with GIC



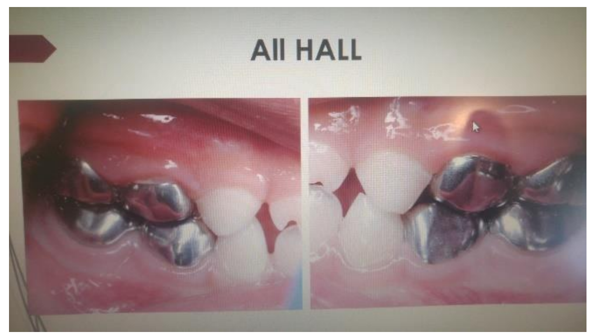
Courtesy Dr. Thierry Boulanger, Brussels.

"97% of SSCs treated with the Hall technique were successful when compared with 94% of SSCs that were placed conventionally. Also, of the SSCs placed with the Hall technique, none resulted in harmful symptoms, whereas 5 of the SSCs placed by conventional means failed due to infection." (JADA, 2015)

Courtesy Dr. Thierry Boulanger, Brussels.

So Why Add the Anti-Microbial Effects of SDF with Hall?:

Modifying the Hall technique by applying SDF to decayed dentin first, before placing SSCs with GIC, could possibly result in even greater success. Can we achieve better results using non-invasive measures? Is this not a HIGHER standard of care?



References

Cardoso, M. V., Delmé, K. I. M., Mine, A., Neves, A. de A., Coutinho, E., De Moor, R. J. G., & Van Meerbeek, B. (2010). Towards a better understanding of the adhesion mechanism of resin-modified glass-ionomers by bonding to differently prepared dentin. Journal of Dentistry, 38(11), 921–929. https://doi.org/10.1016/j.jdent.2010.08.009

Craig, G. G., Powell, K. R., & Price, C. A. (2013). Clinical evaluation of a modified silver fluoride application technique designed to facilitate lesion assessment in outreach programs. BMC Oral Health, 13(1). https://doi.org/10.1186/1472-6831-13-73

Dashper, S. G., Catmull, D. V., Liu, S.-W., Myroforidis, H., Zalizniak, I., Palamara, J. E. A., … Reynolds, E. C. (2016). Casein Phosphopeptide-Amorphous Calcium Phosphate Reduces Streptococcus mutans Biofilm Development on Glass Ionomer Cement and Disrupts Established Biofilms. PLOS ONE, 11(9), e0162322. https://doi.org/10.1371/journal.pone.0162322

Gilchrist, F., Howell, J. L., Gavens, D. P., North, S., Innes, N. P. T., & Rodd, H. D. (2011). Clinical outcomes for preformed metal crowns placed by dental undergraduates. International Journal of Pediatric Dentistry, 21(s2), 12. https://doi.org/10.1111/j.1365-263X.2011.01167_5.x

Gruythuysen, R., van Strijp, G., & Wu, M.-K. (2010). Long-term Survival of Indirect Pulp Treatment Performed in Primary and Permanent Teeth with Clinically Diagnosed Deep Carious Lesions. Journal of Endodontics, 36(9), 1490–1493. https://doi.org/10.1016/j.joen.2010.06.006

Horst, J. A., Ellenikiotis, H., & Milgrom, P. L. (2016). UCSF Protocol for Caries Arrest Using Silver Diamine Fluoride: Rationale, Indications and Consent. Journal of the California Dental Association, 44(1), 16–28. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4778976/

Innes, N. P. T., Ricketts, D., & Evans, D. J. P. (2007). Preformed metal crowns for decayed primary molar teeth. Cochrane Database of Systematic Reviews, (1). https://doi.org/10.1002/14651858.cd005512.pub2

Innes, N.P.T., Evans, D. J. P., & Stirrups, D. R. (2011). Sealing caries in primary molars: randomized control trial, 5-year results. Journal of Dental Research, 90(12), 1405–1410. https://doi.org/10.1177/0022034511422064

Innes, Nicola PT, Marshman, Z., & Vendan, R. E. (2010). A Group of General Dental Practitioners' Views of Preformed Metal Crowns After Participation in the Hall Technique Clinical Trial: A Mixed-Method Evaluation. Primary Dental Care, 17(1), 33–37. https://doi.org/10.1308/135576110790307672

Ludwig, K. H., Fontana, M., Vinson, L. A., Platt, J. A., & Dean, J. A. (2014). The success of stainless-steel crowns placed with the Hall technique. The Journal of the American Dental Association, 145(12), 1248–1253. https://doi.org/10.14219/jada.2014.89

Marchi, J., de Araujo, F., Fröner, A., Straffon, L., & Nör, J. (2006). Indirect Pulp Capping in the Primary Dentition: a 4 Year Follow-up Study. Journal of Clinical Pediatric Dentistry, 31(2), 68–71. https://doi.org/10.17796/jcpd.31.2.y4um5076341226m5

Mount, G. J. (2002). An atlas of glass-ionomer cements : a clinician's guide. London: Martin Dunitz.

Randall, R. C., Vrijhoef, M. M. A., & Wilson, N. H. F. (2000). Efficacy of preformed metal crowns vs. Amalgam restorations. The Journal of the American Dental Association, 131(3), 337–343. https://doi.org/10.14219/jada.archive.2000.0177

Ricketts, David, Lamont, T., Innes, N. P., Kidd, E., & Clarkson, J. E. (2019). Operative caries management in adults and children. Cochrane Database of Systematic Reviews, (3). https://doi.org/10.1002/14651858.cd003808.pub4

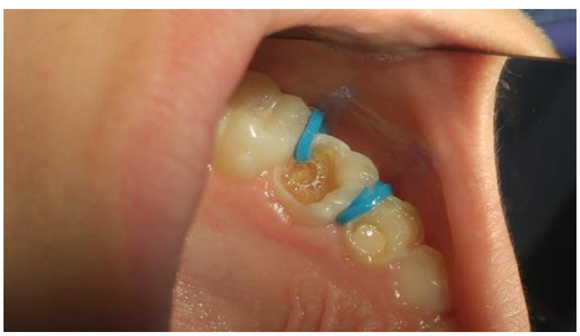
Schwendicke, F., Dörfer, C. E., & Paris, S. (2013). Incomplete Caries Removal: A Systematic Review and Meta-Analysis. Journal of Dental Research, 92(4), 306–314. https://doi.org/10.1177/0022034513477425
Seale, N. S. (2002). The use of stainless-steel crowns. Pediatric Dentistry, 24(5), 501–505.

Hall Case Studies

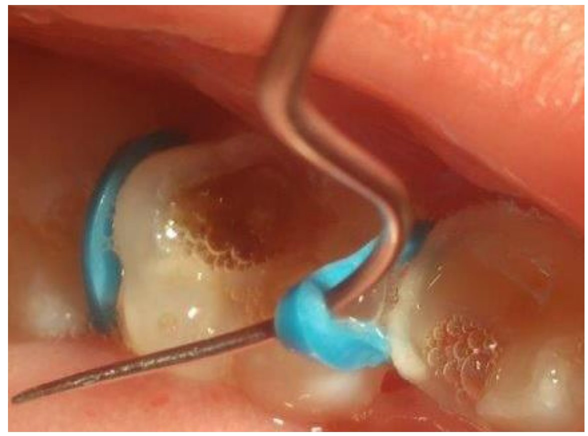
(Dr. John Frachella, DMD)

Case Study #1

This is a 6 1/2-year-old with Extensive caries in #J and K. Note faint shadow of tooth separators placed in preparation for SMART Hall crowns.



Making space for a SMART Hall crown with orthodontic tooth separators placed mesial and distal to #J.



Removal of orthodontic tooth separators from #K after they were in place for 20 minutes.

Removal of mushy decay in # K using spoon excavator, no anesthesia, and using patient's response as a "depth gauge". If a child indicates any discomfort whatsoever, DO NOT go deeper but you can go further with peripheral excavation as long as there's no sensitivity.

SDF is applied to all decay, in this case into the dried lesion in #J. After SDF application, the tooth is left damp with 38% silver ions solution containing 62% water.

#K immediately after seating Hall crown filled with a slow-setting, thin-filmed RMGI (Fuji Cem Plus in this case) over SDF-moistened decay and before excess un-set RMGI is removed.

Immediate post op view of the SMART Hall crown cemented on #K after un-set excess Fuji Cem RMGI was removed. Also please note the completed SMART done on #L (SDF sealed in with Fuji Automix LC RMGI) which was completed at the same time as the Hall crown on #K Post-op SMART Hall Crowns finished on #J and K.

Immediate post op SMART Halls on #J and K in occlusion showing temporary bite opening which will self-resolve in a few weeks.

Case Study #2

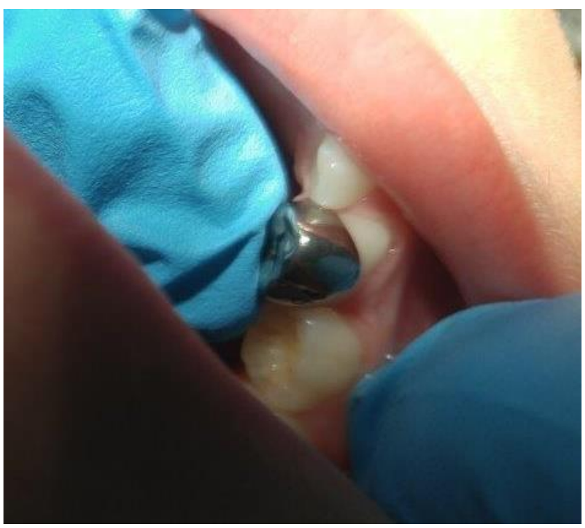
Here's another 6-year-old patient:

#S shown with an orthodontic tooth separator in place (in this case, only on the distal because there's plenty of space mesial to #S for a Hall crown to fit).

Gently remove mushy decay with a spoon excavator. The un-anesthetized child is our "depth gauge": if the patient registers discomfort, never excavate deeper.

Apply SDF to arrest the remaining unexcavated caries.

The lesion has now been SDF-saturated so it immediately begins to turn dark.



The crown is gently seated to test-fit.

A thin-filmed, slow self-setting RMGI (like white Fuji Cem Plus or blue Fuji Ortho) is used to fill the inside of the crown evenly from the bottom up taking care to avoid incorporating air bubbles.

The crown is seated for a final time and excess RMGI is removed before it sets.

Case Study #3

This 4-year-old arrived at her first ever dental exam with 4 badly decayed second primary molars that were treated a-traumatically non-traumatically with SMART Hall crowns. She had never been to a dentist before today!

#A, J, K and T were SMART Hall-ed, all in less than 30 minutes with no needles and no drills.

Immediately post-op, she's biting down with an anterior open bite that was temporarily created by placing her new SMART Halls. She had to eat a softer diet for a few weeks, but her open bite self-corrected quickly.

Silver Fluoride, SMARTs, and Hall Crowns are Good Enough for Anyone.

(Dr. Jeremy Horst, DDS, PhD)

Introduction

I share the story of this patient's dental care to exemplify the strengths and limitations of the contemporary medical management of caries (MMC) techniques that have largely been introduced into the US in the 2010s. These techniques are Silver Fluoride (Silver Diamine Fluoride, SDF; or Silver Nitrate with Fluoride Varnish, SN+FV), High Viscosity Glass Ionomer Cement (HV-GIC) and its use in silver-modified atraumatic restorative treatment (SMART), and Stainless-Steel crowns placed using the Hall technique (Hall crowns). MMC techniques have achieved more rapid adoption (2014-2019) than any other previous caries treatment. A major reason for rapid adoption is that MMC techniques satisfy the limitation of traditional dental restorations in controlling the disease and they obviate the pharmacologic means taken to enable them in young children, people with special healthcare needs, people with severe caries, people with limited financial resources, and older adults. Yet, these techniques are relevant to anyone with caries: this patient with severe special healthcare needs received my first placement of Silver Fluoride after becoming a pediatric dentist, my first SMARTs, and my first Hall crowns; but since seeing this dramatic success I have performed these exact procedures for well children with practically infinite financial and logistical resources. MMC techniques are good enough for anyone.

This patient, JJ, is the child of parents with average to high dental IQ and upper middle-class socioeconomic status. The Mother had been going to the same pediatric dental office for 30 years since she was 3. Upon receiving her as a patient, I removed a symptomatic third molar with a large advanced cavitated carious lesion (ICDAS 6), the only lesion in her mouth, and "graduated" her to a general dentist. The next day she transferred care of her son to me. At 5 years 2 months, he had a range of medical conditions and underlying anatomic anomalies that severely impacted his life and health (Figure 1). The dietary regimen taken to sustain his growth caused him to have severe early childhood caries.

Figure 1: Patient JJ.

Here we follow the course of his dental visits to demonstrate the shift in the patterns of caries activity once he started MMC therapy.

Dental Visits

At 2 years 9 months JJ first presented to a pediatric dentist for routine care. He was non-verbal and non-ambulatory. He had been diagnosed with cerebral palsy, seizures partially managed by Phenobarbital, asthma partially managed with Albuterol, and an atypical cardiac malformation. A papoose was used for restraint during the exam. Caries was diagnosed on the lingual of the upper left primary central incisor (#F). One month later the lesion was restored with a Plastic Resin restoration under restraint by papoose. Restraint was chosen by the provider and parents to manage the patient during treatment at this appointment and those below, as opposed to pharmacologic methods, due to medical fragility. Fluoride Varnish was placed for prevention at this and every remaining dental visit.

At 3 years 1-month recurrent caries was diagnosed around the restoration as was a new lesion on the upper right primary central incisor (#E). Plastic Resin restorations were placed.

At 3 years 3 months 8 new lesions were diagnosed in the fissures of all 8 primary molars. A Plastic Resin restoration was placed on the upper right first primary molar (#B). One month later Plastic Resin restorations were placed on the remaining first primary molars (#I,L,S) and the lower second primary molars (#K,T). One month and a half thereafter Plastic Resin restorations were placed on the upper second primary molars (#A,J).

At 3 years 7 months no caries lesions were found and the restoration margins appeared intact.

At 3 years 10 months he was seen by a new provider for an exam by knee-to-knee restraint. Recurrent caries was diagnosed around the restorations on the primary central incisors (#E,F) and new lesions were diagnosed on the laterals (#D,G). The parent refused general anesthesia due to multiple recent complex sequelae following general anesthesia for non-dental procedures, which were attributed to the anesthesia itself. The provider was concerned about the stress of papoose restraint and offered to try to perform the treatment with knee-to-knee restraint.

At 3 years 11 months he was seen for treatment of the upper incisors. His physicians had recently added Topomax to the Phenobarbital to manage his seizures, and Pulmicort for his asthma. Based on the lack of physical stability achieved, the provider decided it was impractical to perform the intended procedures of pulpotomies and crowns. A more careful intra-oral examination revealed recurrent caries around all restorations and new lesions in inciso-lingual pits of the upper left first primary canine (#H) and the proximal surfaces of the lower central incisors (#O,P). General anesthesia was more strongly recommended and planned with the advanced pediatric anesthesia team of the regional children’s hospital.

At 4 years 1-month JJ was treated under general anesthesia (GA). The lower primary molars (#K,L,S,T) received Stainless Steel crowns (SSCs). The upper left primary central incisor (#F) was diagnosed as necrotic due to history of pain and a sinus tract stoma, and therefore extracted. All remaining teeth with lesions (#A,B,E,H,I,J,O,P) received new composite resin restorations. Two days later he was admitted by anesthesia for somnolence, pneumonia, and fever, and treated with antibiotics. He was released the next day, re-evaluated for fever and airway instability two days later, and admitted to receive IV antibiotics. Two weeks post-GA treatment he was seen in the dental clinic and was well.

At 4 years 8 months he was seen by a new provider who kept him in his wheelchair. No new or recurrent carious lesions were observed.

At 5 years 2 months he was first seen by the author. He recently had surgery on the muscles of his feet, and subsequently was hospitalized for fever and infection. Baclofen had been prescribed for a movement disorder related to the seizures.

He was kept in his wheelchair with the mother helping for stabilization on this and all subsequent appointments. All Plastic Resin restoration sites had recurrent caries, with some fillings lost (#A,E,I,J) due to severe bruxism and recurrent caries. New lesions were observed on all previously unfilled teeth (#C,D,G,M,N,Q,R). Only the crowned teeth were without caries. Hygiene was perceived as adequate per plaque levels and gingival health.

The cause of the caries was diagnosed as frequent use of Pediasure, a food-like product with 12-18g of sugar per serving, prescribed to promote his growth amidst his difficulty eating solid foods. The mother said consumption was unlikely to change, and to the present day 5 years later he remains on frequent use.

Prevident was prescribed to help manage the caries disease. Due to severe risk of aspiration pneumonia, severe infection risk, and the outcome of the previous GA dental treatment, the mother refused to consider GA to enable further traditional restorative care. I offered to attempt caries arrest with the combination of Silver Nitrate and Fluoride Varnish as described by Dr. Steve Duffin (CDA Journal, 2012), warning that it would stain black all hypo- and de-mineralized surfaces. The mother took Dr. Duffin's paper home to the father and grandmother, who all together consented to treatment. Two weeks later Silver Fluoride was applied to all new and recurrent lesions.

At 5 years 6 months Topomax had been added to help manage increasing seizures. All caries lesions except that in the upper left first primary molar (#I) were black throughout. Those that could be assessed with a probe were hard. The one lesion was stained from the margins to 1mm from the center, but the central 2mm was white, fluffy, and sticky – obviously active. Silver Fluoride was reapplied to all lesions at this visit and 7 weeks later.

At 5 years 10 months JJ was brought for re-evaluation and treatment. Over the past year he had various surgeries, each of which was followed with complex infections keeping him admitted for approximately two weeks at a time. After a tonsillectomy and adenoidectomy a month prior he was admitted for 8 days into the PICU due to complications of general anesthesia and pulmonary edema. Advanced workup revealed: hemophilia due to deficiencies in Factors 5,7,10; vitamin deficiencies of B6, D, K (all of which are associated with caries prevention); need for increased medications to stabilize seizures; and a movement disorder. At this time he was on Phenobarbital, Topomax, and Keppra for seizures, Singular for asthma, and Baclofen for his movement disorder. At this visit he had been out of the hospital for two weeks.

All lesions were diagnosed as arrested (Figure 2) except that previously noted, which remained similar in appearance and feel. Silver Fluoride was applied to all arrested and the one active lesion. The next day he was hospitalized due to fever and treated with antibiotics for bilateral ear infection.

At 6 years 1-month JJ was brought for re-evaluation and treatment. The mother was concerned about pain in his mouth. She listed

Figure 1: Maxillary (top) and Mandibular (bottom) arches of patient JJ 1 year post-SMART treatment.

signs as “putting things in his mouth more than normal,” “his response to brushing,” and “her sense as his mother,” and pointed to the upper left. I assessed the most likely causes of pain as: the active deep carious lesion in the upper left primary first molar (#I); erupting molars (the permanent first molars were expected to erupt soon and felt close to breaking through); or both. The filling in the upper left canine (#H) had been lost and therefore this tooth could have also contribute to sensitivity, but it was deemed unlikely because the recurrent decay was arrested and stained black. Based on the mother’s perception of sensitivity to cold and sweet, the most likely diagnosis was reversible pulpitis of the upper left primary first molar (#I).

To treat the pain and decrease the chances of needing extraction in this child with hemophilia, no communication, a movement disorder, seizures, and severe infection risk, I offered to place over this tooth a Stainless Steel crown (SSC) using the Hall technique, a treatment invented by Dr. Norna Hall and studied and popularized by Dr. Nicola Innes and colleagues (Br Dent J. 2006; PMID 16703041).

By this time, the fillings on the upper left primary first molar (#B) and the upper right primary second molar (#J) had also been lost due to severe bruxism and recurrent caries, leaving large cavitations. Due to the remnant cavitations and the importance of these teeth for growth, development, and masticatory function, Hall crowns were planned for all four upper primary molars (#A,B,I,J). Two weeks later the patient was seen for orthodontic spacers, but they would not stay in place, indicating that there was already sufficient space to place the crowns.

Three days thereafter, SSCs were fitted, the teeth were cleaned with a prophy cup and brush, and cemented with high viscosity glass ionomer cement (HV-GIC), in this case GC Fuji IX (Figure 2).

So much of the material was mixed to fill the four SSCs that after seating of the crowns, I tried to make use of the material by quickly pushing it into all open cavitations, based on the hope that the HV-GIC would further support the caries arrest by releasing fluoride and other minerals until falling out in a few days. The teeth treated by this later-named procedure, the silver-modified atraumatic restorative treatment (SMART), included the upper left canine that had lost a filling (#H), broad and shallow lesions on the left primary lateral incisors (#G,N) and the lower primary canines (#M,R).

Every three months thereafter, JJ was examined. No new caries lesions have been observed since starting Silver Fluoride therapy.

At 7 years 8 months dental changes were observed. The SSCs placed under general anesthesia on the lower primary molars (#K,L,S,T) had developed fenestrations from the hyper-occlusion of the Hall crowns on the upper primary molars (#A,B,I,J) and severe bruxism. The stain of the arrested caries lesions on the upper anteriors (#C,D,F,G,H) had nearly all disappeared from severe bruxism and the newly diagnosed severe gastro-intestinal reflux (Figure 3). The lower incisors (#N,O,P,Q) had exfoliated and the permanent succedaneous teeth had erupted (#23,24,25,26) without issue. The permanent molars (#3,14,19,30) erupted with mild to moderate hypoplasia; delayed dental development (tooth exfoliation and eruption ages) was anticipated from his medical profile.

Figure 2: Maxillary (top) and Mandibular (bottom) arches of patient JJ 3 years post-SMART treatment.

The primary molars (#K,L,S,T) were thus stabilized by sealing with HV-GIC. The hypomineralization of the permanent molars was treated with Silver Fluoride at that visit, three months later, and then sealed with HV-GIC using the SMART technique (Figure 3).

Every three months thereafter, JJ has been seen for examination while kept in his wheelchair, with his movement managed by his mother or father. No new caries lesions have been observed. The frequency of visits is to maintain his gingival health. If new caries lesions are diagnosed, they will be treated with SDF. If they become cavitated, they will be treated with SMART. The lower canines are now mobile, ready to exfoliate, and still have their SMART fillings four years after placement, despite severe bruxism and severe reflux.

Discussion

The story of this boy's journey through the management of dental caries demonstrates the strengths and weaknesses of each employed treatment option, detailed below.

Dentists are accustomed to **Plastic Resin restorations**. The moment they are placed, they are as good as they ever will be. Then, they are beautiful. Yet in patients with active caries, it is a matter of time before recurrent caries infects the margins and the benefits of the fillings are lost. In patients with severe caries disease, Plastic Resin restorations predictably fail. While they are lovely to place, they are not active against disease.

Stainless Steel crowns (SSCs) have the highest success rate of any dental procedure for treating caries except extractions. A properly placed SSC on a primary tooth will achieve full coverage, going past the free gingival margin such that caries cannot grow. If the pulp does not become necrotic from the lesion and/or the procedure, and the crown remains in place, the tooth will predictably exfoliate at the normal time despite whatever caries activity may occur. Surprisingly, the **Hall technique** for placing SSCs demonstrates beyond a doubt that there is no need for removing tooth structure prior to placing an SSC. The success rates regarding caries are the same, though the pulpal response seems to be better for Hall crowns than traditional SSCs; it appears the use of a dental drill near the pulp is more irritating than bacteria left sealed in without a sugar source. As demonstrated with JJ, the Hall crown can cause severe wear requiring re-sealing of fenestrations in opposing crowns, not practical in all cases with Plastic Resin, but easily completed with HV-GIC.

Silver Fluoride is the simplest treatment for caries. It stains carious lesions black and tastes “like pennies.” It is quick and hardly technique sensitive. Any dental provider can place it including dental assistants and medical personnel who can place fluoride varnish. As shown here with JJ, Silver Fluoride stops most but not all lesions. Some lesions progress and thus monitoring is essential. More invasive treatment is indicated when a lesions grows or is still very active after 6 months. As also shown here, the effect on the overall control of caries disease is powerful. Commonly we see once Silver Fluoride therapy is begun, no new lesions appear, regardless of whether or not the treated lesions are arrested. Additionally, Silver Fluoride can be used to stabilize hypomineralization areas to sensitivity and reduce their susceptibility to caries. This can be buffeted by sealing over, in this case with HV-GIC.

High Viscosity Glass Ionomer Cement (HV-GIC) is clearly the dental filling material of the future. It maintains margins better than any other direct filling material. It releases minerals into the tooth and the surrounding area that make the tooth stronger and more resistant to caries. The nuances of its application are different than Plastic Resin, and these can be exploited as shown here to produce alarmingly successful results. Without any drilling or numbing, HV-GIC was placed with a finger in a patient whose Plastic Resins placed under ideal conditions had all failed, and it lasted 4 years to exfoliation. Like all dental materials, HV-GIC needs to interface with hard tooth structure, not soft carious material. Normally this is only achieved by excavation. However, Silver Fluoride hardened the carious dentin and enamel, producing a material that could strongly bind the HV-GIC. This follows the lessons from Dr. Jo Frencken, inventor of the Atraumatic restorative treatment (ART), in which partial caries removal focused on producing clean cavosurface margins is followed by placement of an HV-GIC. In this case, the chemical interaction of the Silver Fluoride with the carious tooth materials produces the hard tooth structure necessary for binding the HV-GIC, and is thus termed Silver-Modified Atraumatic Restorative Treatment (SMART). As with all fillings, caries can return to the tooth; the most susceptible part is still the exposed margins of the material and the tooth; yet the anti-caries activity of both the Silver Fluoride and the HV-GIC reduce the recurrence and incidence of new decay dramatically.

Summary

A severely medically compromised boy presented with 17 caries lesions across 15 teeth one year after comprehensive restoration under general anesthesia, which had followed a year of failed traditional restorative therapy. Seeking to avoid another round of general anesthesia due to previous near fatal responses, I treated with Silver Fluoride every 3 months. After one year, due to progression of one lesion, I placed Stainless Steel crowns over the primary molars without local anesthesia or operative preparation using the Hall technique. I also placed HV-GIC in cavitated lesions, using what is now called the SMART technique. Since Silver Fluoride therapy started, no new lesions have appeared, now 5 years in (Figure 4). The patient experienced frequent hospitalizations, which appear related to exposure to the dental and hospital settings. This patient’s story exemplifies the lack of disease control by traditional restorative dentistry for patients with severe caries activity and demonstrates the great success commonly observed by the medical management of caries.

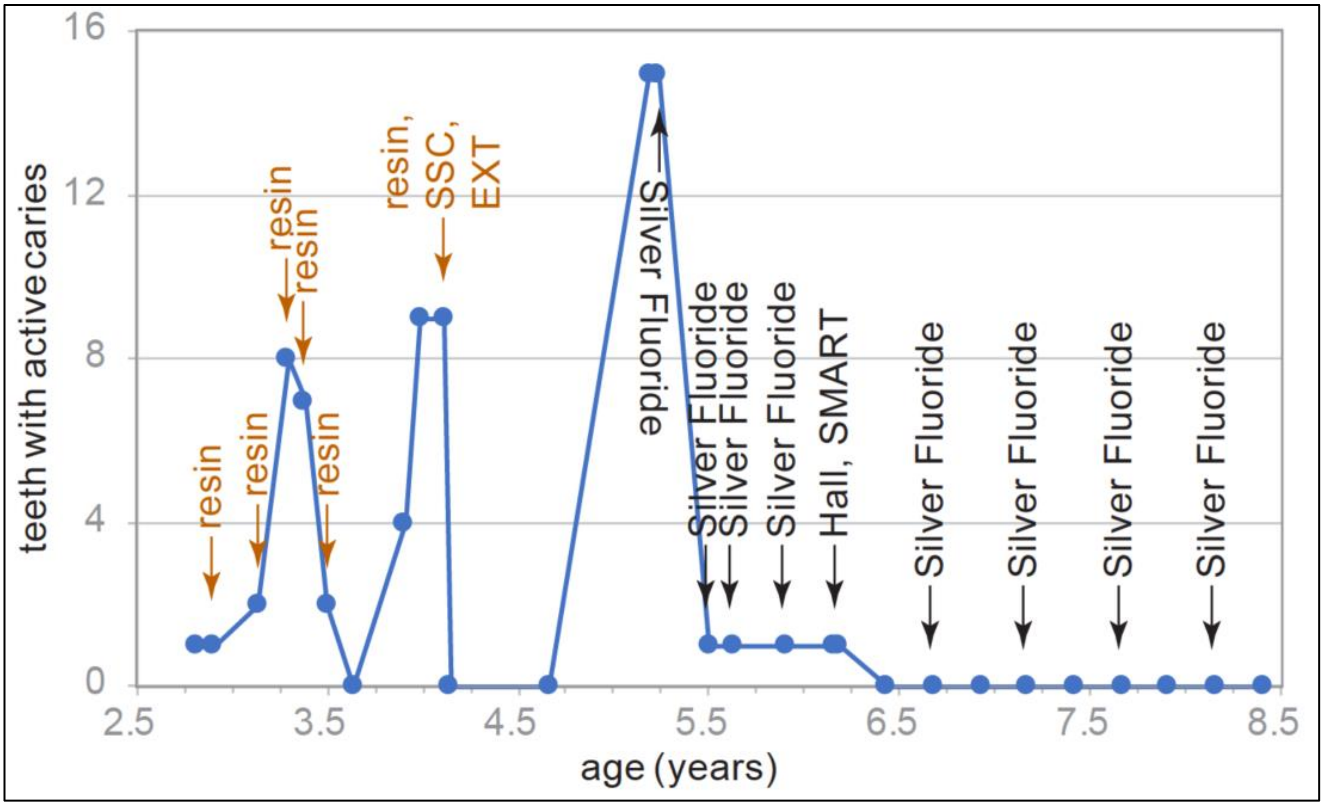


Figure 3: Graph demonstrating caries activity over time following changes in the treatment protocol.

"Please note that the caries activity for this high-risk patient went to zero after Dr. Jeremy Horst began treatment with Silver Fluoride" – Dr. Steven R. Duffin

My Journey to SDF

(Dr. Jeanette MacLean, DDS)

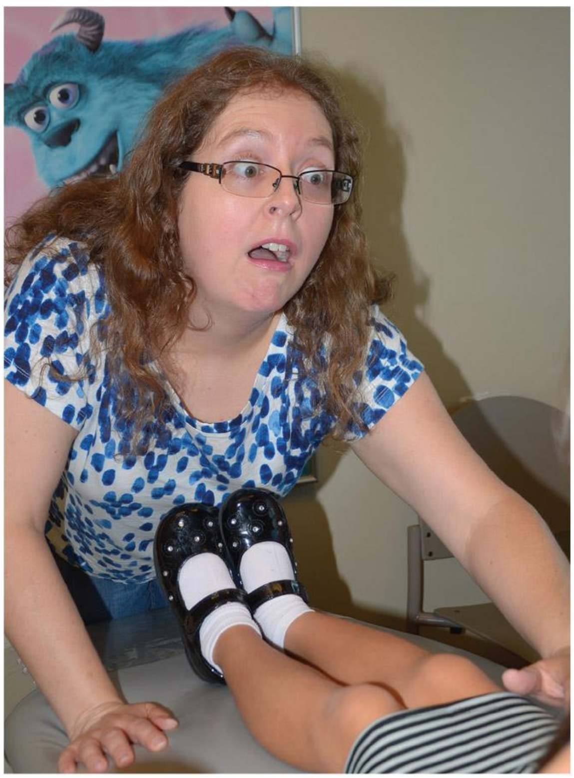
"*I suggest that you carefully consider everything that Dr. Maclean has to say in this section. I certainly did and am inspired by her journey every time I read it.*" – Dr. Steven Duffin

I completed my pediatric dental residency training in Las Vegas, Nevada, where we exclusively treated children on Medicaid. I was trained in a style that I now refer to as "Medicaid Mentality," where our treatment plans were very aggressive; most cases were treated in the operating room under general anesthesia, every interproximal lesion in a molar got a stainless-steel crown, and every little white spot lesion got a filling. We were led to believe this approach was "better" as this could be their "only chance."

Once I got into private practice, I quickly saw that this aggressive treatment approach didn't fly in the real world. Parents, especially those footing the bill, wanted to "watch" whatever we could watch, try a filling instead of a stainless-steel crown whenever possible, and general anesthesia was a last resort. I also made the following clinical observations: more aggressive restorative treatments did not prevent recurrent caries or new lesions on other teeth; improving hygiene did not guarantee my patients would be caries free, and my prevention programs(age one visit, anticipatory guidance, fluoride varnish, etc.) while still important, did not stop caries. It dawned on me that my formal dental education never addressed this problem. The assumption was that the patient should brush and floss regularly; limit eating sugars and refined foods; and see their dentist regularly; improve their poor oral hygiene in our "modern diet" of processed foods loaded with sugar.

There are two major life events that I credit with changing the way I practice.

The first was becoming a mother in 2010. My daughter had surgery at 9 months old in 2012 to remove a branchial cleft cyst in her neck. As they say, the more you know, the more you worry. Stressing over that surgery was one of the most difficult events in my life. As a result, my attitude and approach to dealing with parents dramatically changed. It made a profound impact on the way I spoke with parents and presented treatment. It especially changed the way I presented sedation and anesthesia. Before I had children of my own, I was very nonchalant, perhaps cavalier in the way I discussed anesthesia. It inspired my 2015 article for Dentaltown Magazine, *Parents in the Operatory: Friend or Foe,* in which I discuss evolving from a practitioner trained in the "old style" of parents



Typical "My Poor Baby" Mom

kept out of the operatory, and how I now welcome them and encourage their presence.

The next event that made a profound impact on the way I practice was an emergency with a patient under IV sedation in my office.

These events made me question myself and the way I practiced. I wanted to know what could I do DIFFERENTLY? What could I do BETTER? You could say this was the beginning of my journey to SDF.

I first heard of silver diamine fluoride in a 2014 online dental article by Dr. John Frachella. My initial impression was, "who is this tree hugging quack?"

The irony is that the joke was on me. I soon discovered using silver to treat caries dated back to the late 1800's. Shortly after SDF became available in the United States as Advantage Arrest Silver Diamine Fluoride 38% from Elevate Oral Care in the spring of 2015, I bought a bottle and started using it in my private practice. I now use SDF every day in my practice and it has changed the way I am able to deliver care to my patients and it has changed me as a pediatric dentist. I can say that SDF has made me **DIFFERENT** and **BETTER**. I am happy to report that I have successfully incorporated SDF and (silver modified atraumatic restorative dental treatment (SMART) into my busy, thriving, private pediatric practice.

I was enthusiastic about adding this non-invasive treatment option and posting it all over social media and my practice website. I credit this for leading Catherine Saint Louis (CSL), a New York Times journalist, to contact me. In the summer of 2016, CSL, as I like to call her, called my office and asked to interview me for an article she was working on about SDF. The first time we spoke over the phone she asked if I had a patient that might be willing to have one of the photographers capture me applying SDF to their tooth. I obliged, of course, and began wracking my brain over who would be "the perfect patient" for this historic photo opportunity. My office manager ran a report with all the names of patients who had received SDF treatment. Immediately the choice was clear, Knox Urschel, a charming little 4-year-old boy. Referring to the Times piece, you will recall that Knox's mother is an anesthesiologist. Choosing Herschel to be the "photo op" was no mistake; it was a statement. Here was a, highly educated woman, a physician and anesthesiologist who could afford the very best of dental care for her child and who understands perhaps better than anyone else the risks of sedation and anesthesia, and she purposely chose SDF treatment. Call it my subliminal message to the SDF "doubters" who think parents "won't want black teeth" or that this is somehow "third world care."

Think again. As I am quoted in the article, "A Cavity Fighting Liquid Helps Kids Avoid Dentists' Drills, "

Pure serendipity, on July 12, 2017, Knox came to see me for a checkup on what was the one-year anniversary of the New York Times article appearing in print on newsstands. Pure serendipity. His mother had not made the connection.

> Dr. MacLean said, "People assume that parents will reject it because of poor aesthetics." But "if it means preventing a child from having to be sedated or having their tooth drilled and filled, there are many parents who choose S.D.F.," she added.

After Dr. MacLean treated Knox, she gave him a sticker.
CAITLIN O'HARA FOR THE NEW YORK TIMES

The following day, as though the Universe was screaming at me that week, the special needs patient who had experienced the medical emergency while under IV sedation in my office came for his 3-month recall.

So here I am in 2017, on my 5th bottle of SDF, having treated thousands of teeth and now getting asked to speak around the world on this topic. It's insane.

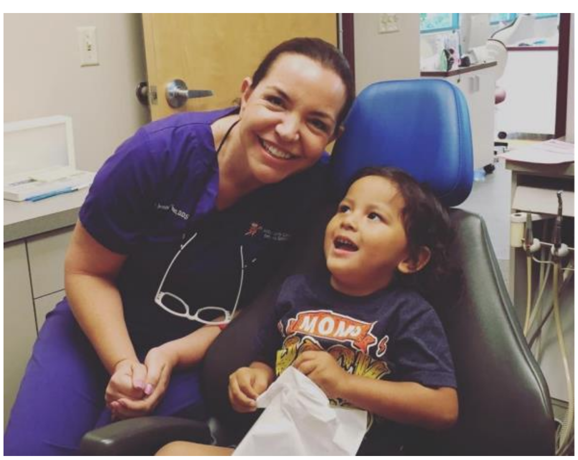
Meet Wyatt

Meet 4-year-old Wyatt, aka "Patient Zero." He is the grandson of a fellow USC Dental School graduate. I have seen him since he was just 1 year old. Until today, his checkups have been a sweaty exorcism filled with stalling, tears, negotiating, etc... When he was just 2 years old I discovered large occlusal caries lesions on his upper first primary molars. We attempted treatment with Versed, which turned into an even grander exorcism than his cleanings, we had to abort the mission. Due to a heart condition, he was not a candidate for in office IV sedation (which I no longer offer). I referred him to another pediatric dentist for treatment under GA in a hospital, which was going to cost mom thousands of dollars to treat 2 teeth. She didn't know what to do. I offered her SDF and a 3-month recall. And every 3 months she came, we did his sweaty prophylaxis/fluoride & reapplied SDF to #B & I. After just one application his decay was arrested, but I just 'didn't know' what was going to happen next. It made me nervous. It made me uncomfortable, but I did it to help them. And it worked like magic!! Today was particularly special because it was the first day he actually sat in the chair, not on our laps, and did not cry for ANYTHING. He even hugged me and let me take a picture with him afterwards. Mom & I were so happy we had tears in our eyes. I just wanted to share this story. Don't be afraid to try something different. It just might work for you too. I'd rather post this than some pretty composites that failed. I'll take these black diamonds any day. He might even let me put some GIC over them next time.

So very fitting that on this day, the one-year anniversary of the New York Times silver diamine fluoride article, that this little man, Wyatt, came back to see me. You might recall he was one of my very first SDF patients and a former behavioral nightmare. He was having pain yesterday while eating Skittles (😱😂 we had a talk about that), but just as I predicted back in March when we had our first behavior breakthrough, today he took an X-ray like a champ and let me place SMART fillings in #B & I. I told him how incredibly proud I was of him and took a picture of him with his favorite assistant, Yvette (Rock Star and Saint). This is what it's all about!

Anterior Case

Meet Tasahli



In the wake of the New York Times article, I received patient inquiries from around the country and even around the world. One such patient was Tasahli. His mother read the New York Times article and decided to fly him from their home in Oklahoma to Arizona to see me for SDF.

Meet Tasahli. His mother has now flown him 3 times from Oklahoma to Arizona for SDF treatment because no one in her state gave her any other option but General Anesthesia. His decay is now arrested, and he has only 1 quadrant of restorative treatment left to complete Why not give parents options like SDF and quadrant dentistry? When given a treatment plan of General Anesthesia or the highway, don't be surprised if some of your patients take the highway! I received permission from mom to post this case. She hopes more dentists will offer SDF and she is taking the literature to her tribe she also wants me to open an office in Oklahoma.

Tasahli is back from Oklahoma! And he brought cousins!!! No new lesions, I masked a scar on #G with Shofu + Fuji, I did SDF + SMART on his cousins. Mom and dad are stoked. Life is good. I LOVE MY JOB!!!

I recently learned the name “Tasahli” in Chickasaw means “scream.” I think Tasahli’s mother’s actions are a “scream” for change in the way we deliver care to children.

Before and after anterior SDF arrested case treated with GIC.

The New York Times

A Cavity-Fighting Liquid Lets Kids Avoid Dentists' Drills

By CATHERINE SAINT LOUIS JULY 11, 2016

Dr. Jeanette MacLean, left, and a dental assistant, Stacy Serna, with 4-year-old Knox Urschel, before treating a cavity with silver diamine fluoride in Glendale, Ariz. Credit Caitlin O'Hara for The New York Times

Nobody looks forward to having a cavity drilled and filled by a dentist. Now there's an alternative: an antimicrobial liquid that can be brushed on cavities to stop tooth decay — painlessly.

The liquid is called silver diamine fluoride, or S.D.F. It's been used for decades in Japan, but it's been available in the United States, under the brand name Advantage Arrest, for just about a year.

The Food and Drug Administration cleared silver diamine fluoride for use as a tooth desensitizer for adults 21 and older. But studies show it can halt the progression of cavities and prevent them, and dentists are increasingly using it off-label for those purposes.

"The upside, the great one, is you don't need to drill and you don't need an injection," said Dr. Margherita Fontana, a professor of cariology at the University of Michigan.ingly using it off-label for those purposes.

Silver diamine fluoride is already used in hundreds of dental offices. Medicaid patients in Oregon are receiving the treatment, and at least 18 dental schools have started teaching the next generation of pediatric dentists how to use it.

Dr. Richard Niederman, the chairman of the epidemiology and health promotion department at the New York University College of Dentistry, said, "Being able to paint it on in 30 seconds with no noise, no drilling, is better, faster, cheaper."

"I would encourage parents to ask for it," he added. "It's less trauma for the kid."

Knox Urschel, 4, had a liquid treatment, silver diamine fluoride, brushed on a decaying tooth. Studies have shown that the antimicrobial liquid can halt the progression of cavities and prevent them. Credit Caitlin O'Hara for The New York Times

The main downside is aesthetic: Silver diamine fluoride blackens the brownish decay on a tooth. That may not matter on a back molar or a baby tooth that will fall out, but some patients are likely to be deterred by the prospect of a dark spot on a visible tooth.

Until more insurers cover it, patients also have to cover the cost. Still, it's relatively inexpensive. Dr. Michelle Urschel, an anesthesiologist, was happy to pay $25 to have Dr. Jeanette MacLean, a pediatric dentist in Glendale, Ariz., paint over a cavity that her son Knox, 4, had recently developed. A cavity that had to be drilled cost $151. The liquid "was very affordable," Dr. Urschel said.

The noninvasive treatment may be ideal for the indigent, nursing home residents and others who have trouble finding care. And many anxious dental patients want to dodge the drill.

But the liquid may be especially useful for children. Nearly a quarter of 2- to 5-year-olds have cavities, according to the Centers for Disease Control and Prevention. Some preschoolers with severe cavities must be treated in a hospital under general anesthesia, even though it may pose risks to the developing brain.

"S.D.F. gives us an opportunity to decrease the number of toddlers with cavities going to the O.R.," said Dr. Arwa Owais, an associate professor of pediatric dentistry at the University of Iowa.

Dr. Laurence Hyacinthe, a pediatric dentist in Harlem, used silver diamine fluoride on eight uncooperative children whose parents wanted to delay a trip to the operating room.

Dr. MacLean said, "People assume that parents will reject it because of poor aesthetics." But "if it means preventing a child from having to be sedated or having their tooth drilled and filled, there are many parents who choose S.D.F.," she added.

After Dr. MacLean treated Knox, she gave him a sticker. Credit Caitlin O'Hara for The New York Times

Alejandra Bujeiro, 32, was delighted that her 3-year-old daughter, Natalia, didn't have to have two cavities filled in the back of her mouth. Instead Dr. Eyal Simchi, a pediatric dentist in Elmwood Park, N.J., brushed silver diamine fluoride on the decay. Two front teeth, however, were drilled. Next time, Ms. Bujeiro said, she'd opt for silver diamine fluoride. "I would use it in baby teeth even if it's in front," she said. As for the discoloration? "You can't see it too much."

Silver diamine fluoride has another advantage over traditional treatment: It kills the bacteria that cause decay. A second treatment applied six to 18 months after the first markedly arrests cavities, studies have shown."S.D.F. reduces the incidence of new caries and progression of current caries by about 80 percent," said Dr. Niederman, who is updating an evidence review of silver diamine fluoride published in 2009.

Fillings, by contrast, do not cure an oral infection."There's nothing that goes on in an operating room that treats the underlying problem," said Dr. Peter Milgrom, a professor of pediatric dentistry at the University of Washington who was instrumental in receiving F.D.A. clearance for silver diamine fluoride and has a financial stake in Advantage Arrest.That's why some children must have dental treatment under anesthesia twice.

Knox getting a high-five from Dr. MacLean after being treated with silver diamine fluoride. The cost of the treatment: $25. By comparison, a filling would have run $151. Credit Caitlin O'Hara for The New York Times

Bacterial infections also cause acne, but a "dermatologist doesn't take a scalpel and cut off your pimples," said Dr. Jason Hirsch, a pediatric dentist in Royal Palm Beach, Fla. Yet "that's how dentistry has approached cavities." Dr. Hirsch has a Facebook page called SDF Action, where dentists can discuss individual cases.

In January, Oregon became the first state to reimburse Medicaid providers for treating cavities with silver diamine fluoride. "It's a completely new paradigm" that offers "significant savings," said Dr. Bruce W. Austin, the dental director of the Oregon Health Authority.

"You need only a drop to treat five teeth, and it comes out to pennies per tooth," said Dr. Scott L. Tomar, a University of Florida dentistry professor who treats some Medicaid patients.

Toddlers in low-income families sometimes have to wait a year for fillings in an operating room. The new alternative is "a huge deal," said Dr. Tomar, the chairman of the oral health section of the American Public Health Association.

Silver diamine fluoride also may help nursing-home residents, who often experience severe cavities if their teeth aren't routinely brushed. Transporting and treating frail patients, assuming they can afford to see a dentist, can be difficult. But now some patients can be quickly treated where they live.

Still, silver diamine fluoride is no silver bullet. Patients with mouth sores or a silver allergy can't use it. Severe cavities — huge holes that trap food and plaque — still require fillings.

At dental conferences, Dr. Tomar and Dr. Fontana lecture about the treatment. They ask audiences if they are using it; so far, just a few hands go up.

A version of this article appears in print on July 12, 2016, on page D5 of the New York edition with the headline: Dodging the Drill With Cavity-Fighting Liquid.

The Top 5 Misconceptions about Silver Diamine Fluoride

(Dr. Jeanette MacLean, DDS)

On July 11, 2016, I was featured in the New York Times article, "A Cavity-Fighting Liquid Lets Kids Avoid Dentist's Drills." Since the article was released, there has been a surge of public interest and dialogue amongst dental professionals regarding silver diamine fluoride (SDF). Some positive and some negative. As a member of various online dental forums, I followed several SDF related threads in the wake of the article. What I found interesting was that the negative comments tended to stem from misconceptions and a general lack of knowledge. It's no surprise that the majority of modern-day dentists never used or perhaps never heard of SDF until the Times article came out. For most of us it was not part of our dental education. I went to a very old, well-respected dental school, and when I first heard of SDF in a 2014 online dental article, I thought, "what is this tree-hugging quackery?!" Well, turns out the joke was on me and this method of treating decay can be traced back to the 1800's. The father of modern dentistry himself, G. V. Black, is said to have used silver nitrate extensively to treat decay in children in the early 1900's. (Duffin. "Back to the Future: The Medical Management of Caries Introduction." J Calif Dent Assoc 2012;40:852-8.) It has been used in other countries such as Japan, China, and Australia for decades. There are twelve randomized clinical trials that tout its efficacy in the U.S., the use of silver products to treat caries seemed to have vanished into obscurity in the 1950's when we introduced 'painless' dentistry with better anesthesia and added fluoride to toothpastes and water. Apparently, we thought we would eradicate decay, and if an issue did arise, it wouldn't be "painful" to have it fixed. Well it's 2017 and sugar is king, and the cavities are rampant, especially in the Southwest where I practice. 91% of the American population has caries according to the latest CDC data. It has become increasingly apparent that we cannot simply "drill" our way out of this problem. Unfortunately, our prevention programs (exams, prophylaxis, and fluoride varnishes) are not cutting the caries incidence rates in high risk individuals. There has to be a better way. Unlike surgical dentistry, or "drill and fill," SDF treats the bacteria and biofilms causing the decay. Shortly after Elevate Oral Care's Advantage Arrest SDF 38% came on the market in 2015, I ordered a bottle and started using it. I now use it on a daily basis for patients in a wide array of scenarios. I hope more dentists will open their minds and expand their knowledge base by reading up on SDF and introducing it to their practices. Let us start by addressing what I consider to be the *5 Most Common Misconceptions about Silver Diamine Fluoride*.

Number 1: It's Going to Run You Out of Business

I thought an angry mob was going to come for me with pitchforks and torches after my patient's parents disclosed to the New York Times reporter, Catherine Saint Louis, that they paid me $25 to place silver diamine fluoride on their 4-year-old child's incipient carious lesion. Pediatric dentists were in a state of panic that they were on the verge of bankruptcy because someone helped a child out in a humane and affordable manner. Oh the humanity! I honestly find this misconception quite laughable. The procedure takes mere minutes, often done the same day as the exam, with little more than a microbrush. For about 50-80 cents a drop, Advantage Arrest SDF can treat up to 5 lesions. It can be used on incipient lesions you would normally "watch" and check again in 6 months. We offer patients same day application of SDF on non-cavitated incipient lesions. Very few insurance companies currently reimburse D1354 (caries arresting medicament), but most parents are more than willing to pay out of pocket for SDF for their children. Ironically, your routine exam and cleaning actually becomes MORE productive, and you've given the patient a better chance of being caries free at their next check-up. It's a win-win.

There's nothing more frustrating as a pediatric dentist than to have hours of time blocked out for a sedation patient only to have them no show, cancel last minute due to illness, or violate NPO status. Talk about a waste of time and money. Simple, quick, yet effective treatments like SDF and SMART (Silver Modified Atraumatic Restorative Treatment) allow you to treat more patients in a shorter period of time by eliminating the need for local anesthetics and sedation. Because SDF is a fluoride, often a hygienist or expanded function dental assistant can apply subsequent treatments of SDF to arrested lesions, freeing up the dentist's time to examine and treat other patients.

The key fact to remember here is that SDF does not restore form or function, nor is it cosmetic. There will still be fillings, crowns, extractions, cosmetic dentistry, implants, etc. SDF isn't putting anyone out of business, it is just another tool in the tool kit for fighting decay, and any notion otherwise is simply unfounded. I now use SDF in my private practice on a daily basis. We have enjoyed an increase in new patients, improved retention of existing patients, and increased internal marketing via word-of-mouth referrals. I have dramatically reduced our minimal oral conscious sedations cases, eliminated the use of in-office IV sedation, and rarely have the need to refer a case out for General Anesthesia, all while maintaining a thriving, seven-figure producing practice. This financial misconception is expanded upon in example number 4.

Number 2: Patients Will Reject it Due to Poor Aesthetics

I attended a 2015 pediatric lecture in which the speaker, a very well-respected pediatric dentist, took a completely dismissive stance on SDF and said that parents would reject it due to cosmetics. They asserted that they "won't want black teeth." Well I beg to differ. There are plenty of parents who, when given the option, choose SDF for their children. I see these patients on a daily basis. Their reasons vary considerably: no insurance coverage, lack of funds, fear of sedation, recent birth, divorce, move or change of employment, age, behavior, special needs, medical issues, tooth eruption timing, the list goes on. SDF advocate Dr. Jason Hirsch of Royal Palm Beach, FL, shares a similar sentiment, "perception leads to barriers, but barriers are often overcome with discussion, education, and resourcefulness." Of course, some parents choose the more cosmetic treatment option, but it's giving them all of the information and options and empowering the parent to make the decision that will set you apart as a practitioner.

The number 1 reason I see patients for a second opinion is that they weren't given another choice**.** It was GA or the highway. Often the parent's concerns regarding sedation and general anesthesia are entirely dismissed. Parents who don't want or can't afford treatment for their child end up just hopping from office to office, or just disappearing altogether. In my mind, the SDF treatment is better than no treatment at all. When it comes to black stains, fillings, or crowns, we shouldn't be the ones to decide what parents want. We should give them all of the options, review the pros and cons, and let them decide for themselves. You might be surprised how many opt for the less-invasive, less-cosmetic, but highly effective choice of SDF.

Number 3: It's Only for Children

Patients of all ages can benefit from the use of SDF. The University of California, San Francisco, School of Dentistry identified five indications for the use of SDF: 1. extreme caries risk (such as those individuals with salivary dysfunction secondary to cancer treatment), Sjorgen's syndrome, polypharmacy or methamphetamine abuse for whom prevention visits and traditional restorations fail to stop the disease progression. 2. Treatment challenged by behavioral or medical management (such as the frail elderly, immunocompromised, those with severe cognitive or physical disabilities and those with dental phobias that are not good candidates for anesthesia due to the medical complexity). 3). Patients with carious lesions that cannot all be treated in one visit (such as the slow-moving pace of a dental school setting, county clinics that could be booked out for several months, or someone unable to complete treatment in a timely manner due to insurance or financial issues). 4). Difficult to treat dental carious lesions (such as partially erupted molars, recurrent caries at a crown margin, root caries in a furcation). 5). Patients without access to dental care.

The use of SDF has huge potential for our overburdened public health system. It has an unprecedented ability to help treat decay in the most vulnerable patients such as the elderly and Medicaid populations. Dr. Peter Milgrom from the University of Washington and Dr. Mike Shirtcliff of Advantage Dental were instrumental in gaining FDA clearance for SDF in 2014. Thanks to forward thinking dentists like Dr. Shirtcliff, along with Drs. Steven Duffin, John Frachella, and Cate Quas, the state of Oregon helped put SDF back on the map. In January 2016 Oregon became the first state to reimburse Medicaid providers for treating cavities with it. In October of 2016, the FDA granted Advantage Arrest Silver Diamine Fluoride 38% the Breakthrough Therapy designation for caries arrest, making it the only oral medicine to ever receive this prestigious recognition.

Adults can also benefit from SDF treatment to target the disease process first, then address restorative and cosmetic dentistry second. Since fillings and crowns are not cariostatic, much of the dentistry that is performed on adults is re-do dentistry for margins that are decayed or simply discolored. Why not use SDF to arrest marginal decay and then seal the margins? This has been advocated by evidence based meta-analysis. Yet too many restorations are being removed and the death spiral of re-do dentistry is alive and well. We must break this pattern of not treating the disease first. Why not give your patients the option to treat incipient lesions at a crown or filling margin in a conservative manner? Your patients will love you for it, and they will tell all of their friends. Further, SDF was FDA cleared to treat dentin sensitivity, just like fluoride varnish which holds the same classification and is also used off-label to prevent decay. Using SDF can decrease the odds of recurrent decay and/or postoperative sensitivity with your restorations.

Number 4: Patients Will Not Get Treatment Completed

The sentiment I've heard from many colleagues about SDF is that they fear patients will never get their treatment done. First of all, SDF **IS** treatment. It is a non-invasive, medicinal approach to managing the bacteria that is actually contributing to the decay in the first place. Fillings and crowns do not do that. SDF does not restore form or function to cavitated teeth. However, combining SDF with glass ionomer cement, known as SMART (Silver Modified Atraumatic Restorative Treatment), makes an excellent restoration. SDF as an indirect pulp therapy along with a stainless-steel crown, or Hall crown, is another viable option. When a new patient comes in wanting SDF and they have giant holes that will trap food, I educate them that yes, I could apply SDF, but ultimately the tooth will need a restoration to prevent food impaction and/or space loss. Further, not every tooth is a candidate for SDF. Teeth with abscesses and lesions involving the pulp are not eligible for this treatment modality.

Shortly after the Times article was published, I had a mother bring her two-year-old child to me all the way from Oklahoma in favor of quadrant dentistry vs. general anesthesia. In the end it cost her more money and time, but she didn't care. For her "all at once" was too much and she had great safety concerns following two tragic, highly publicized, deaths of children receiving dental treatment under anesthesia l. Where is the harm in listening to our patients and their concerns or, within reason, accommodating their needs? Second opinions for IV and general anesthesia are now commonplace for me and it is not unusual to have a patient come from across town or even out of state to receive non-invasive care. As I mentioned earlier, the main reason patients come to me for a second opinion is that they weren't given other options elsewhere. The notion that an aggressive surgical approach is the superior and only choice is sadly misguided. In fact, gold standard OR/GA pediatric dentistry has relapse rates of between 20 and 80 percent. The treatment planning discussion is an important opportunity to educate patients that fillings and crowns are not cures for caries, nor is SDF. If the behaviors such as poor diet and hygiene persist, these treatments will ultimately fail, and the caries can and will return.

Number 5: You Can't Bond to it

I have received numerous emails and viewed concerned and confused posts on multiple online dental forums where dentists ponder whether or not they can cement crowns or bond adhesive restorations to SDF treated tooth structure. The answer is yes. Dr. Ryan Quock of the University of Texas School of Dentistry at Houston conducted an *in vitro* study to examine whether silver diamine fluoride (SDF) applied to non-carious permanent dentin would adversely affect bond strength of resin composite. Their results indicated that there were no significant differences in micro tensile bond strength of composite to control versus 38% SDF treated dentin samples. The same was true whether etch-and-rinse or self-etch adhesive was used Another study by Dr. Ivy Wu, performed on primary teeth, yielded similar data. In light of these results, it seems that bonding is compatible with dentin pre-treated with SDF. Dr. Quock does recommend the mechanical preparation of enamel and the DEJ to remove demineralization. The purpose of which is to maximize bond to sound tooth structure and improve the marginal seal.

It is important to be aware that light curing any restorative material on the same day that you apply SDF will pose an aesthetic issue. The curing light will precipitate the silver out of solution and turn the entire restoration gray. Further, even placing a self-curing high viscosity glass ionomer cement (HV-GIC, the preferred material for SMART) on the same day that SDF is applied, will eventually turn the material gray. This can be avoided by placing your restorative material at a separate visit than the SDF application. High quality HV-GICs, such as Fuji EQUIA Forte, are often opaque enough to mask SDF arrested caries. If you need to place a resin composite or resin modified glass ionomer (RMGIC) on the same day as your SDF application, I recommend simply light cure the SDF after is it applied and prior to placement of the resin. The excess stain can be polished off sound enamel using a slow speed tufted prophy brush and plain pumice prior to etching and placing your light-cured restorative material. Universal opaquers, such as Shofu Beautifil, can also effectively mask the black scar under resins or RMGICs, such as Fuji II LC, if desired. Trying these techniques on extracted teeth is helpful to gain experience prior to using the product on a patient for the first time. Of course, this is a non-issue if aesthetics is not a concern.

Conclusion:

When current modes of prevention and restorative treatment fail to control caries, it raises the question, what could we do differently? What could we do better? Twetman and Dhar concluded in 2015 “there is lack of substantial evidence to suggest that restorative treatment leads to acceptable long-term clinical outcomes,” and “there is certainly a need to go beyond the drill-and-fill dentistry and integrate other concepts of disease management to ensure long-term success.” Is our profession ready for a paradigm shift to a medical management of caries model, one that incorporates early intervention with topical antimicrobials like SDF as a first line of defense? One that utilizes minimally invasive restorations with biocompatible materials such as glass ionomer cements whenever possible? The abundance of evidence-based data supporting the efficacy of SDF is too strong to ignore. As dentists we owe it to ourselves and our patients to never stop learning, never stop reading, and never get too comfortable or stuck in our current mode of thinking. I encourage you, my colleagues, to read the evidence for yourself. SDF is not a panacea, but it is a powerful oral medicine which satisfies the CMS triple aim of healthcare (increases access, improves health, and reduces cost) and a welcome addition to our toolkit.

Treating the Interproximal Lesion

(Dr. Jeanette MacLean, DDS)

Arresting a lesion that is developing in the interproximal space is particularly difficult. The reason for this is the complexity of placing silver ion compounds into direct contact with the lesion. One approach is to place orthodontic separating bands until a temporary space is achieved between the teeth where the lesion is located. Then it is easy to dry the area and place SDF followed by fluoride varnish. Another technique is to place a separating wedge or StimuDent between the teeth to achieve the same space immediately.

Increasingly clinicians are using the “Super Floss” technique. This entails placement of a strand of super floss between the teeth, then placement of a drop of SDF on the floss just to the lingual of the tooth and pulling the floss to the facial, until the SDF soaked floss is directly over the lesion. Radiographically, an arrested interproximal lesion fails to grow, but will appear to be the same size for long periods of time. In some cases, these lesions will remineralize from the salivary mineral reservoir and become more radio dense on future radiographs.

Demonstration video by Dr. MacLean

- https://www.youtube.com/watch?v=Q8dgVQG8i0o

Here's a case I posted to social media today; 12-20-2017 Dr. MacLean. This 12-year-old has had interproximal caries and restorations on every primary molar, except #S (class 2 resins and SSCs). I'm hoping to spare his permanent molars the same fate using SDF and the Interproximal Superfloss Technique (despite him not brushing at night and only flossing 'sometimes' 😬😅 we chatted about that...). So far, so good... and now that #K and #T have exfoliated, and #20 & #29 haven't fully erupted, it was a nice learning lesson for him to see the arrested lesions so he could see what he's missing with his brush that he needs to floss, that black 'scar' is nice and smooth and hard, and will not be visible once the adjacent teeth fully erupt. It's also nice to see just how well the SDF absorbs interproximally on the Superfloss, and why separators and disking are completely unnecessary. He had his 3rd SDF application yesterday. For incipient lesions like this, I reapply q6mo for approx. 2 years (about 4 total applications) or until the teeth exfoliate (like #K & #T) or the surface remineralizes and looks more opaque and/or no change in depth, size or contrast. I didn't even reapply to #19 & 30 yesterday, because they were clearly arrested and stable. I just applied it between the upper molars (3,A,J,14). — at Affiliated Children's Dental.

SDF arrested incipient lesions From prior Application using interproximal SuperFloss

Dr. Jeanette MacLean kidsteethandbraces.com

"Hint…..*Leave silver in the tooth*!" - Dr. Steve Duffin

Dr. Eyal Simchi Clinical Cases

(Dr. Eyal Simchi, DMD)

Clinical Cases:

In July/August of 2015 Adi AGE 5 was seen by a pediatric dentist close to where she lives. She was told at the office that she had extensive dental needs including multiple teeth requiring pulp treatment and SSCs. The pediatric dentist informed her parents that G.A would be needed due to her age and the extensive treatment necessary.

Adi's mom was very nervous about the idea of G.A. and wanted to consider other options but wasn't sure what to do. After speaking to some friends, she was directed towards the July 2016 NY times article about SDF. After doing some research she was able to find our office and came in for a consult. Adi's first visit was in August 2016. She was shy and reserved but very cooperative. After a few silly jokes and some magic tricks Adi sat still beautifully for an exam. We discussed less invasive options with her parents including the use of SDF and SMART restorations to stabilize her dentition. Adi's parents were informed that more treatment would be needed at a later date but that these treatments could work well in conjunction with habit changes at home to stabilize Adi's dental infection and hopefully slow the decay process in her mouth**. In early August 2016 we applied SDF to all of Adi's molars after confirming that adequate dentin remined over the pulps and that she was symptom free.** At that visit we confirmed significant habit changes including brushing/flossing and diet changes. In September Adi followed up for another application of SDF and then returned for SMART restorations. From September 2016 until February 2018 Adi continued to present for follow ups and re-application of SDF. At her last visit we chose to restore #J-MO which had been

monitored since her initial visit. Her family made the 4+ hour drive multiple times until her treatment was complete.

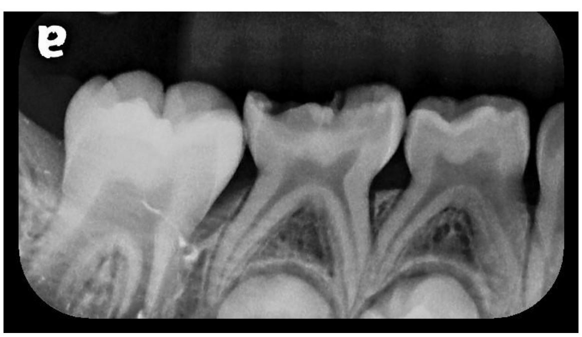
Additionally, the family made significant changes to diet and home care habits. **At this time, she has no active decay, has no fear of going to the dentist and her teeth are stable.** All of Adi's treatment was completed with no sedation and no use of local anesthetic either.

Here is a copy of the beautiful review dad left us. My wife brought our five-year-old daughter to see Dr. Simchi from Syracuse, NY (about a four-hour one-way drive). We were told by a local pediatric dentist that she had cavities on 15 teeth, five needing stainless steel crowns and four of those needing pulpotomies. We were told there was no suitable alternate treatment and oral surgery was advised.

A few days later, my wife read the New York Times article about silver diamine fluoride in which Dr. Simchi was interviewed. She was unable to find a local dentist who uses it, so she made the appointment with Dr. Simchi, despite the distance. Upon examination he said pulpotomies were unnecessary, he could treat her teeth with SDF immediately, and within a few additional visits he would restore the areas that needed more attention.

Not only was this treatment plan a huge emotional relief, it was also an enormous cost savings (over $3,000). On top of his skill and expertise, he is wonderful with children. Our extremely shy daughter quickly warmed up to Dr. Simchi during her first visit and looks forward to going back (especially to see his magic tricks). We'll gladly drive the distance to take our daughter to her appointments. We highly recommend him. Thank you Dr. Simchi!

Ezzy was 5 when he first presented for treatment. While reviewing his medical history his mother reported SVT (super ventricular tachycardia.) Due to his condition, the patient's cardiologist recommended avoiding anesthetics containing epinephrine. The option available is carbocaine which because of its shorter duration of action would not provide enough time for extensive treatment. Additionally, especially for patients with cardiac issues, keeping the patient stress and pain free is of paramount importance. Due to multiple doctor's visits this patient was already very apprehensive. After a discussion with his parents, we decided to attempt to arrest the decay until cooperation was improved or until the patient underwent ablation surgery to reduce his risks from SVT. At the initial appointment in 2015 GIC was placed over the sensitive tooth to rule out pulpal symptoms. (2 stage treatment can be helpful in assessing reversible vs irreversible pulpitis). About 5 months into treatment SDF became available in the U.S. Because the GIC had already chipped/worn away we decided to continue treatment with SDF and then another layer of G.I.C. This was completed in November 2015. At this point cooperation was already much better due to the increased trust and the appointments had all been quick and pain free. On x-ray you can see dentin bridging under the SMART restoration. And finally, in 2017, after re-application of SDF and adding more GIC during 2016, we decided to crown the tooth to protect it from further attrition/fracture. Here you can see that the tooth is now stable with no further treatment needed. (no L.A. was used for this case)



Pre-treatment radiograph

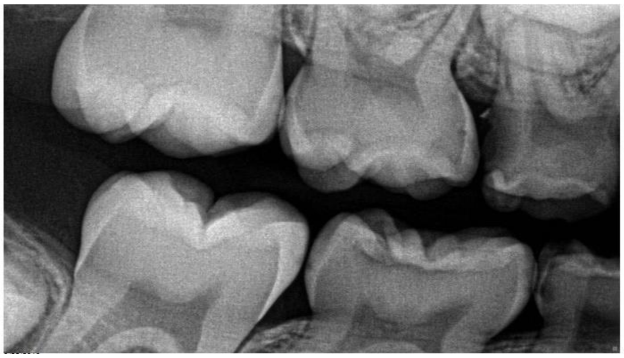
Another Case Review

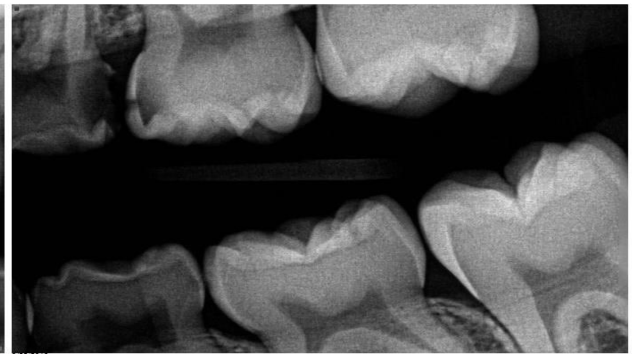
I had gone to 3 pediatric dentists prior to Dr. Simchi and none of them had the patience to deal with my daughter's dental anxiety. When she finally had x-rays, it turned out she had cavities that needed to be filled. Her dentist at the time couldn't even get her to relax enough to Give her nitrous oxide. He sent us off with a list of dentists who do sedation dentistry. This made me unhappy. I found Dr. Simchi while researching alternatives to fillings. I set up a consult after reading all his wonderful reviews.
His office was beautiful, modern and the staff was welcoming. His demeanor was very comforting, and his patience was just what we were looking for. My daughter was all-in once he broke out the magic tricks and Netflix. I can't say enough positive things. I do not have an easygoing child. He has managed to fill her cavities without even resorting to nitrous oxide, he also used the silver fluoride where he could; and he sealed her back teeth to prevent decay. The last time I said, "we have to go to the dentist" my daughter replied with "I hope it’s the dentist I like!” Yes, Dr. Simchi is a true magician.

Krushna’s Case

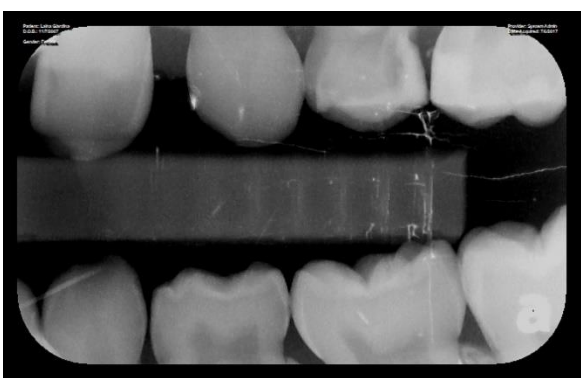
Although his previous dentist had said that the only way to complete Krushna’s case was with sedation, after slowly gaining Krushna’s trust, I was able to stabilize his dentition. Starting with SDF done in the waiting room and then slowly working our way back into the operatory to continue with SMART restorations and Hall crowns, I eventually was able to restore form and function to Krushna’s many badly decayed teeth with no tears.

Krushna is a sweet 10-year-old who presented to the office with large carious lesions on multiple teeth. Due to his anxiety he would not cooperate with his previous dentist who then





recommended sedation. At our first visit I discussed treatment options with Krushna's mom and decided together that attempting SDF followed by SMART would be the least invasive option. Above are his presenting x-rays. At the initial visit I applied SDF to all areas of decay and scheduled follow up treatment. On the way out of the operatory, I could already tell that his anxiety had abated. He seemed more relaxed and was not upset when he saw his mother make his next appointment. After another appointment to apply SDF, I restored his upper left teeth using fuji II, a resin modified glass ionomer which can be seen in the below radiograph and images to the right are completed treatment.



More Updates from Dr. Eyal Simchi

Behavior management has evolved over time. Dentistry is one of the very few invasive medical procedures routinely done on young children without consistently sedating them. It is also one of the most commonly done.

The AAPD guideline for behavior management says, " A dentist who treats children should be able to accurately assess the child's developmental level, dental attitudes, and temperament and to anticipate the child's reaction to care". The responses to the demands of oral health care are complex and determined by many factors.

History of Behavior Management

Historically, Pediatric dentistry has had a "get it done philosophy." Earlier behavior management techniques include hand over mouth, restraint, parental separation and voice control. While some of these techniques are still in use to a limited extent today and can be effective, they are less accepted and often traumatizing to today's patients. Studies show a decrease in parental acceptance of more aggressive behavior management techniques with a trend in some cases towards sedation/G.A.. While sedation and G.A. can be effective and atraumatic, they are not without risk as recent news reports from around the country are reporting. Below are some of the techniques used:

Restraint

Although still used by many practitioners, The AAPD guidelines for use of restraint do not include routine use for multiple quadrants of treatment. Restraint is reserved for specific situations where there are no other safe options. Restraint is contraindicated for "non-emergent treatment needs" in order to accomplish full mouth or multiple quadrant dental rehabilitation or for the practitioner's convenience.

HOME/Voice Control

Techniques such as the HOME (hand over mouth) were taught and were done for many years. This technique is still discussed in the 2011 edition of McDonald and Avery. These techniques are not acceptable in today's standards and can contribute to significant trauma to a child. Voice control can work but as parenting styles have changed pretty drastically they are much less effective. Additionally, parents are often unhappy with this method.

Sedation/G.A.

For children with extensive treatment needs who are uncooperative, sedation has been one of the only options. Conventional treatment requires more time and cooperation from the patient to be done safely and effectively. It is sometimes impossible to comfortably treat patients in an office setting with conventional treatment, sedation is often recommended. Unfortunately, sedation and general anesthesia are not without risk. Over the past few years multiple pediatric fatalities in dental offices have made the public aware of the inherent risk with these practices. Even with cases that go smoothly without incident, the possibility of negative long-term effects of anesthesia on the developing brain of a child have not been fully researched. New research is pointing towards adverse effects on the developing brain especially with multiple uses of G.A. Because of these reasons, parents as well as practitioners do and should look for safe and effective alternatives. Additionally, even treatment completed under the ideal situation of the operating room is often not enough to stop the progression of the disease. Many children who undergo treatment under anesthesia end up requiring anesthesia again in the future. These important reasons should help guide a practitioner to utilize the SMART techniques described.

Reasons for Needing Behavior Management Include:

1. Age
2. Extent of treatment
3. Previous history of negative dental experiences
4. Special needs medical diagnosis

In my opinion being less authoritative and more nurturing works much better with my patients.
Our practice tries to do things differently. Changing perceptions about dentistry is a difficult task but one that we have worked hard to achieve. My philosophy in treating children begins and ends with trust. When there is trust in a dentist/patient relationship it is far easier in my experience for patients to tolerate the sensitivities inherent in dentistry. I still remember what aspects of my dental visits I had a hard time with as a child. The list ranges from the hard time I had with the strong tastes, to the gritty texture of the prophy paste to the difficult gag reflex I still deal with today. Even smelling an office that reminds me of my childhood dental visits often makes me cringe.

Sensitivities Commonly Encountered in a Dental Office Include:

1. Tastes
2. Smells
3. Textures
4. Gag reflex/drowning feeling
5. Bright lights
6. Loud noises
7. Vibrations
8. Suction feeling
9. Laying back

To help work past these sensitivities and the negative perceptions of dentistry for my patients we have evolved our practice in the follow ways:

The first step is to get a feel for the patient's previous dental experiences and background. Obtaining a good history will help the process immensely. Knowing if a child has had a bad experience can help make their next experience better. When I do have a patient that has had a previous negative experience, I try to gather as much information about that experience as possible. This includes discussing the parents' feelings about what happened and also asking the patient what particular parts of the visit they didn't like. Something as simple as bright lights or strong smells can make a sensitive child upset. Once you have a better understanding of the child's likes/dislikes you can adapt the visits to work around them.

Rushing into things with pediatric patients will often end with bad results. Moving slowly allows familiarity and ensures that you don't miss any pertinent information. In our office, first visits begin in the waiting room. For patients who have had negative experiences often this may be the whole appointment. A quick hello in the waiting room, a prize or sticker and a magic trick are usually enough to get a child who is hiding behind a parent to come out and give you a high five. At times I have even gone out to a patient's car to say hello before the patient is willing to come into the office.

Being flexible is essential. Our meet and greets are not scripted. Because each child has their own personality and likes and dislikes, the appointments vary. The appointment consists of as little as a quick hello in the waiting room but will often include a tour of the whole office, magic tricks, and silly jokes.

Krushna (one of the cases presented above) was brought to our office by his concerned parents after being told that he would need G.A and that there was no other way to treat him. His first visit began with him crying in the waiting room that he did not want to go back to the treatment room. After some magic tricks and jokes he allowed us to take him for a quick tour of the office and although he wouldn't stay in the treatment room he had already calmed down considerably. Once back in the waiting room, my assistant brought out a hygiene set up tray and a cordless prophy handpiece. Using Tell-Show-Do and slowly progressing we were able to complete his entire exam and cleaning in the waiting room. As I describe below, his subsequent visits went very well. This is a good example of how being flexible can help.

I ask the parent to fill out a questionnaire developed to help a practitioner to get an idea about how well a young patient will do at a dental visit.

The questions include:

1. Past medical procedures and behavior, at pediatrician office.
2. How has your child reacted in the past for medical procedures?
3. Child's perception of his/her oral health.
4. Does the child perceive that something is wrong?
5. Parental anxiety/fear.
6. How do you feel about going to the dentist?
7. Parental expectations.
8. How do you feel your child will do?

The policy in my office is to avoid doing any significant treatment at the first visit. Patients who start their dental journey with a clean slate are always easiest for me. But even patients with no preconceived negative feelings towards dentistry get upset if overwhelmed. For patients with cavities who are nervous at their hygiene exam I often take out an artificial mouth typodont. We start by making a cavity using a sharpie marker and then work together to clean out the cavity "tooth bugs" with our "bumpy toothbrush . We then fill with princess polish or superman polish depending on the patient's preference.

Another significant technique is the use of creative wording. Wording is everything in our practice. It can change a patient's perception from terror to fun. We even go as far as to ask parents not to prepare their child with anything more than a dental storybook before appointments. I explain to parents that something that seems as innocuous as saying "don't worry it won't hurt" can be taken differently by a young child. Saying it won't hurt leaves the impression that pain could be a possibility and can be built up rather quickly in a young patient's mind. Below is a list of some replacement words we use very often.

Pain/hurt → bothers/uncomfortable

Drill → fire engine or bumpy guy

Shot → sleepy juice/drip near tooth

Topical Anesthetic → jelly

Filling → princess/superman polish

Crown → princess/robot tooth

Another technique that works well is modeling. Allowing a patient to watch a typical visit can help alleviate some of the fears and preconceived ideas that can be built up before a visit. I will often allow a younger sibling to act as our assistant for their older sibling. This allows the patient to see with a close-up view what actually happens during an appointment. In many cases this is enough to help the patient jump into the chair when itis their turn.

These techniques are great to help get a patient comfortably into the dental chair but what happens once they are in the chair? My goal is a healthy mouth in a happy child. Both are equally important. Getting the work done without regard for the patients feeling or ability to tolerate treatment will give the child healthy teeth but will likely also give the child an unhealthy view of oral care. This is where taking sensitivities into consideration is very important. For some children something as little as the lights being too bright is too much. For this, I have found that a headlight worn on loupes gives me the best results. The light goes just where you want it without the peripheral shine you get from a typical overhead dental light. I have also installed dimmers for the ceiling lights and keep sunglasses on hand for those especially sensitive.

Although there are sensitivities that are fairly easy to deal with, some are impossible to avoid. Tastes, sounds and smells are ubiquitous in our practices. Because there are things we can't change, managing expectations can make the difference between a good and bad visit. Giving choices will give the patient a sense of control and make them part of the process. As I said before, silly jokes sprinkled in can keep the feeling fun and not as overwhelming. For example, in our practice we tell our patient that we will be using a cool toothpaste to clean their teeth and offer them the following flavors: Smelly socks, skunk, tuna fish, diaper and spoiled milk. We then give the real options which in this context now seem much better than they might have alone. Preparing a patient properly before they experience something they perceive as negative can also be extremely helpful. For instance, before using a bonding material with a strong smell, I will warn my patient that we will be using something that makes their tooth super strong but that it is also super stinky. We then explain that the light will stop the smell very quickly while curing the material.

Attempting to have time limits for steps helps in many cases. Knowing that something will take 3,5 or 10 more seconds can be comforting when compared to sitting there without knowing how long something will last. I like giving choices where appropriate and counting fits beautifully together with that. When I need 5 more seconds to complete a task I will ask the patient if they would like to do 20 more seconds, 10 more or 5 more. In most cases they will pick the shortest time and that is the time I need to complete the task in the first place. Giving the patient a sense of control will greatly add to their trust. Knowing that what the dentist says will always be true allows the patient to relax a little.

The next technique I use almost always is hand raising. Raising a hand is a signal to stop. This again gives the child a sense of control over a situation that cause them fear or anxiety. Often times children will test the limits and raise their hand continuously. Even in these cases, I recommend stopping each time to show your patient that you keep to your word. If the hand raising becomes excessive you can calmly explain that hand raising is reserved for really important stops.

Unfortunately, even utilizing all of these techniques is sometimes not enough for certain patients. Very young children have limited coping mechanisms to deal with situations they perceive as frightening even after much has been explained. Patients with special needs can have the same difficulties. Older children with no specific special needs can tolerate limited amounts of work, but not tolerate longer appointments when treatment needs are extensive.

More invasive treatments often require significantly more patient cooperation to get good results. The difference in cooperation needed to anesthetize a patient, place a rubber dam for isolation, complete a pulpotomy, prepare the tooth for a stainless-steel crown and cement an SSC versus placing SDF for an IPC and then a Hall crown are immense. This is where minimally invasive techniques come into play.

Even in cases where treatment is done under ideal circumstances failure rates are high. Some studies show that over 50% of dentistry done in the U.S. is replacement of previous treatment failures. So not only is conventional treatment more difficult for many patients, it often isn't a long-term fix anyway!

SMART stands for Silver Modified Atraumatic Restorative Technique. It is based on ART. It improves on ART by including SDF into the equation helping increase the success by addressing the underlying cause of decay, bacteria. With SMART we are able to utilize materials available to dentist for decades and are able to more predictably restore function and health to our patients without compromising on their dental or mental health.

In our office SMART is used in multiple ways. I use it for very young children to buy time and stabilize the dentition until more extensive treatment can be completed without trauma. At times we use the SMART technique to help patients who have had previous negative experiences work past their fears by accomplishing small goals and gaining trust. I even use SMART restorations for high risk patients who do not have significant dental phobias because I feel that unlike conventional treatment, with the use of SDF and GIC materials we can help prevent recurrence of decay.

Another comment from Dr. Steve Duffin: I am so inspired by the message that Dr. Simchi has shared with us. SDF allows us to effectively treat caries in challenging patient situations. I want to add that I have had numerous uncooperative child patients who wouldn't even come into our dental office. So what did I do ? I went out to the car where the kid was hiding out with my mobile SDF kit and treated them in the car !!! Now I go to rural villages in Africa and South America and get the same results with NO dental office at all.

The Role of Radiographs in MMC

(Dr. Steve Duffin, DDS)

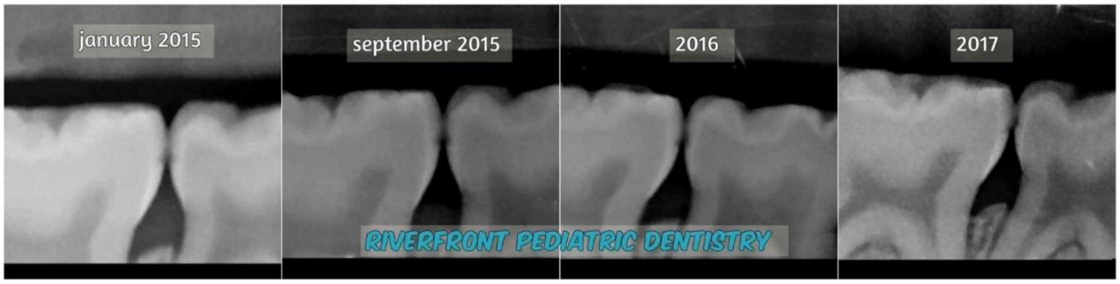


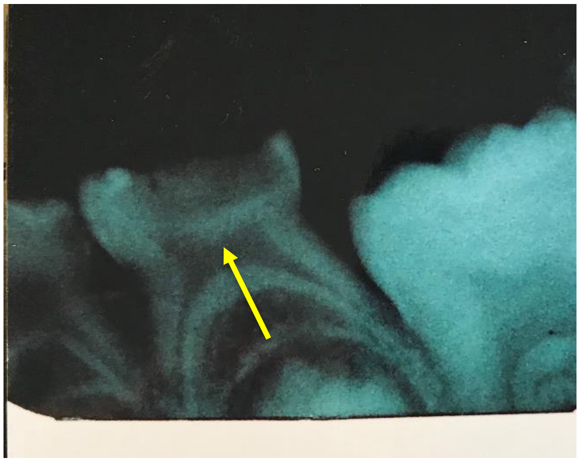
Image provided by Dr. Eyal Simchi.

When determining lesion arrest, the principal identifying characteristics are color and surface hardness. For lesions that are easily seen this is easy to do. For interproximal lesions it is more difficult. When a lesion is identified on a radiograph, then treated with a silver ion product for arrest, we would **not** expect to see the lesion grow in size in future radiographs. We do in fact see remineralization over time due to salivary calcium and phosphate. Fluoride in either toothpaste, varnish or glass ionomer cement, may assist with the development of fluorapatite.

Pulpal Mineralization

Another phenomenon that can be visualized on radiographs is the formation of dentin by odontoblasts that are responding to the presence of a lesion in enamel and dentin. A caries lesion advances in the tooth by way of repeated acid attacks produced by bacteria fermenting carbohydrates. The pulp responds to this insult by the formation of tertiary dentin to insulate the pulp from the advancing lesion. By neutralizing the bacteria with silver ions, the protective efforts of the pulp are placed in advantage over the advancing lesion. Another sign of arrest is the radiographic presence of tertiary dentin.

Post treatment halo in primary teeth. Image provided by Dr. Mike Bratlan.



Tertiary dentin formation arrested lesion. Image provided by Dr. Steve Duffin.

This manuscript is not intended to represent a comprehensive description of the science of cariology. The readier is directed to the work of Dr. Edwina Kidd and Dr. Ole Fejerskov. (Kidd E., Fejerskov O., Dental Caries The Disease and its Clinical Management, Blackwell Press, 2015)

Clinicians have reported that lesions which have been treated with silver ion products show a radiopaque halo at the periphery of the lesion. Presumably this is due to presence of silver in this zone. A recent publication on this subject may be of interest to the reader.

*(*Assessment of the Silver Penetration and Distribution in Carious Lesions od Deciduous Teeth Treated with Silver Diamine Fluoride. Y Li, Y Liu, W Psoter, O Nguyen, T Bromage, M Walters, B Hu, S Rabieh, F Kumararaja. Caries Research, February 26, 2019).

Further investigation into this subject is warranted.

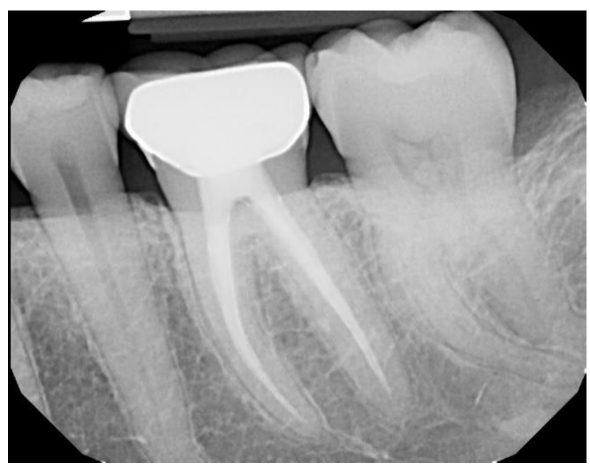
SMART Sealants

(Dr. Steve Duffin, DDS)

Dental sealants remain an example of a preventive intervention with a high degree of scientific evidence (Wright JT, Crall JJ, Fontana M, et al. Evidence-based clinical practice guideline for the use of pit-and-fissure sealants: A report of the American Dental Association and the American Academy of Pediatric Dentistry. J Am Dent Assoc 2016;147(8):672-82 e12.). This is especially true for the six-year molars which are the most highly susceptible teeth in the permanent dentition to decay. The application of silver diamine fluoride to healthy tooth enamel has demonstrated penetration and retention in the interprismatic space up to 100 microns (Geoff Knight personal communication). There exists the potential for synergistic interaction between the SDF and a GIC sealant material, which can be seen in the image to the left.

GIC sealant placement after caries arrest from SDF application post SDF application – image provided by Dr. Steve Duffin.

One common problem with resin sealants is a marginal failure that leads to leakage under the sealant. When this occurs, decay may proceed undetected underneath the sealant. Below is an image showing the radiographic evidence of the treatment outcome for a failed resin sealant. The presence of SDF provides a backup strategy. When a glass ionomer sealant material is chosen, there exists a strong possibility of potentiating the effects of both SDF and GIC as chemotherapeutic agents in the prevention of caries.



X-ray of tooth which required a crown and root canal becasue of a failed resin sealant.

Many clinicians who have adopted SDF in their clinical protocols are employing this strategy with sealant placement, however, much remains to be discovered before we have conclusive evidence to support this approach. Will the placement of SDF replace the need for sealants altogether? We do not know at this time, rigorous clinical trials await, but my sense of curiosity begs an answer.

A Mother's Choice: The Case of Christina and Claire:

(Dr. Steve Duffin, DDS)

A truly remarkable story of a mother who rejected general anesthesia for her one-year old daughter and traveled one thousand miles to receive treatment at the Shoreview Dental Clinic. We have followed her for many years and have seen her normal adult dentition entering a healthy mouth:

Link to interview with Claire and her mother

- https://www.youtube.com/watch?v=4qyhxzYhGmk

The Case of Mr. Robert Block:

(Dr. Steve Duffin, DDS)

Mr. Block is an adult patient who experienced a stroke which impaired the ability to care for his teeth. Our attempts to control his re-occurring tooth decay and gingivitis at my Shoreview Dental clinic in Oregon was an ongoing battle before introducing silver ion therapy. The photo on the right was taken three months after applying silver ion compounds to all surfaces of his teeth. despite the lack of brushing note the absence of plaque and gingival inflammation. I was totally amazed with this finding. This is an interview With Robert many years after beginning treatment with silver ion compounds:

Link to interview with Mr. Block

- https://www.youtube.com/watch?v=-OJ60O3vyIw)

Link to PBS Story, using medicine to treat tooth decay including a visit by Mr. Block:

- (https://www.youtube.com/watch?v=rsZgLB-8-HM&frags=pl%2Cwn)

Dr. David Noel and Allie – Treating Special Needs Patients

(Dr. Steve Duffin, DDS)

The following section is presented as an opportunity for reader reflection. Over several years, I have had the pleasure to know Dr. David Noel and learn of the remarkable story of his personal and professional care for his special-needs daughter, Allie. We have preserved some historical video and compiled a recent interview and demonstration of preventive techniques that I believe will be very beneficial for the reader to examine. This material has been placed on the website below. Please enjoy and thank you David for sharing your story.

- https://www.howtoendtoothdecayandgumdisease.com

Special Cases - The Story of Jake Felix, M.D.

(Dr. Jake Felix, MD)

Steve Duffin and I have been colleagues and close friends since we met in 2008 and discovered a shared commitment to children's dental health. I had recently retired, moved to Portland, and volunteered as a spokesperson for the Oregon Academy of Pediatrics dental health program. Steve was focusing on use of silver nitrate to arrest and prevent caries in young children. This was a perfect fit and we worked together for several years until advanced Parkinson's Disease curtailed my activities greatly.

Summer 2016, I consulted with Steve about my own urgent dental needs. A large cavity between teeth 2 and 3 was discovered at a routine exam. The treatment recommendation was a root canal and crown on tooth 3 and extraction of tooth 2. Prospects seemed unacceptable since it was unlikely that I could tolerate oral surgery due to Parkinson's Disease. Steve said "Jake, let me take a look and maybe we can try the silver treatment on you. It has been used a few times on adults."

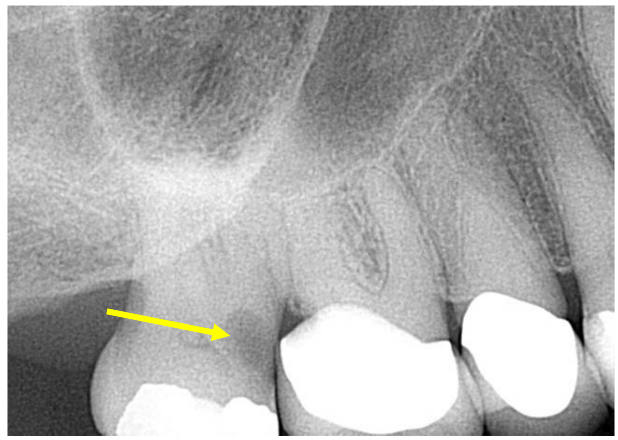
So started a series of visits for x-rays, evaluation and a plan. Silver diamine fluoride was applied at several regular intervals and the caries arrested. The nerves never became involved and no infection or pain developed. The applications took only minutes and had no side effects. I began to use high fluoride toothpaste, Prevident 5000, daily to enhance the healing. Once treatment was proven effective based on repeat observations and x-rays, Steve filled the open gap with a temporary material (GIC) to keep it clear of food. The GIC broke off or came loose a few times and was replaced with another trial substance. As of October 2017, trials with fillers continues.

From my perspective, this process is a total success. Putting aside probable high costs of dental surgeries, the real and critical benefit was avoiding the procedures and consequent risks altogether at a time when I was basically home bound due to PD and unable to sit still for more than a few minutes. This was a godsend for me.

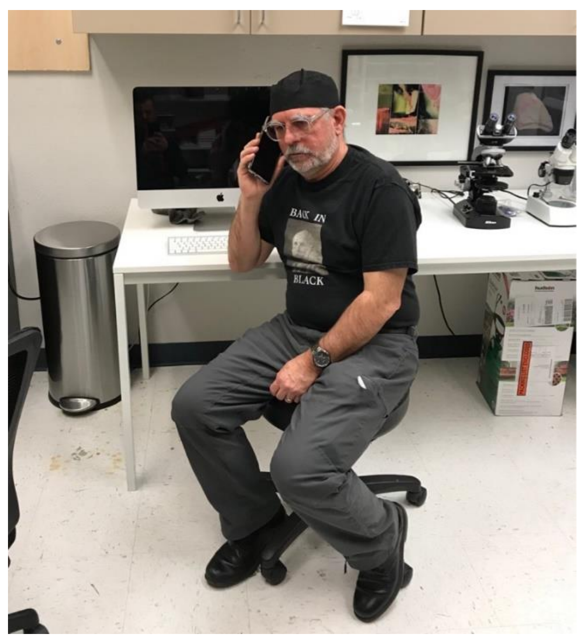
I hope Steve can use my case as further demonstration that the SDF approach is effective and preferable in situations like mine. And from my wife Jeanette's perspective, a huge weight of worry was lifted. She knows that surgery and any anesthesia can result in cognitive damage in PD patients. We both couldn't be more pleased and more proud of Steve's pioneering work.

"While continuing to provide in home care for Jake Felix it became necessary for Jonalee Potter RDH and I to collaborate using teledentistry technology. This method of collaboration greatly extends the value and effectiveness of the medical management of caries in clinical practice." -Dr. Steven Duffin

Dr. Duffin and Jonalee Potter, RDH treating Jake at his home.



Radiographic evidence of deep decay in maxillary second molar.



Teledentistry care with Steve Duffin and Jonalee Potter.

Dr. MacLean Case Report

(Dr. Jeanette Maclean, DDS)

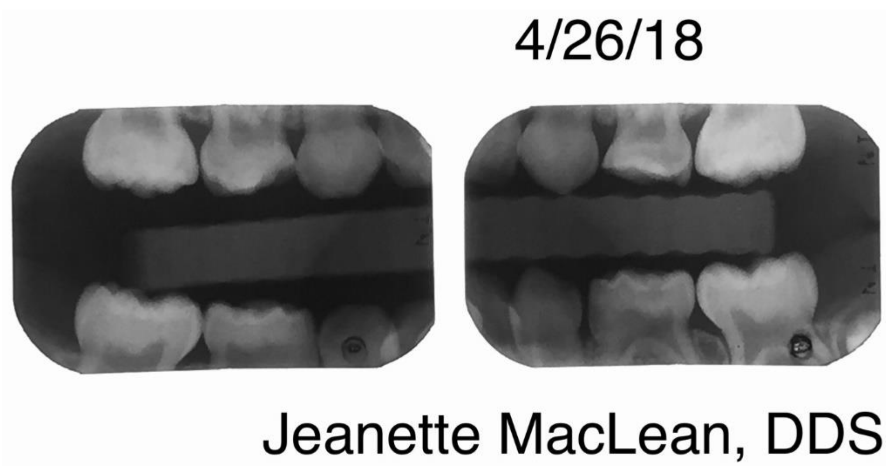
Folks, this is a long-term case I am sharing widely today (AAPD Little Teeth Chat, Facebook forums, and Dentaltown). I figure it is better to constructively help those with an open mind vs. argue with those suffering from willful ignorance. You're welcome to use any and all images.

Minimally Invasive Case Study: this is a wonderful clinical example of minimally invasive, non-surgical treatment options for SECC which demonstrates where SDF can be used alone (in areas that are the most likely to arrest with behavior change, lesions that are open to saliva, and easily cleansed of biofilm). It also demonstrates decision making for treatment of areas where SDF alone is less likely to be a long term solution and where a minimally invasive restoration, such as SMART or SMART Hall, would be of benefit for sealing out food and biofilm, and for durability (in areas where caries are less likely to arrest due to fissured grooves and/or cavitated lesions/broken down molars that must withstand years of mastication forces). I began treating this patient at 2 years of age in 2016. She had a history of on demand breastfeeding and night nursing, difficult behavior for brushing. We reviewed caries etiology, diet, hygiene, etc. Her teeth were asymptomatic. I reviewed treatment options of traditional surgical interventions with sedation or minimally invasive options beginning with SDF. Mom did not want to sedate her, so we began with SDF only in the Fall of 2016. The PAs were the best handheld films we could get. In the Spring of 2017 I placed SMARTs (ART/ITR, potato - po-tah-toe) on B and I. In the Spring of 2018 I placed a SMART on L (new lesion). In the Spring of 2018 I placed Hall crowns on B & I, because the EQUIA Forte was not holding up as well as I would have liked due to the size of the lesions and limited cooperation for placement. I did a total of 4 applications of SDF to her incisors. They are shiny, hard, black and arrested, diet and hygiene have improved, so I see no need to reapply. Today was her routine visit. Everything is stable, no new lesions, she is a happy kiddo, willingly hops in the chair and cooperates for everything. Many ways to approach this case, just wanted to share another option as there is increasing awareness and demand among parents for minimally invasive treatment options. Total cost of the minimally invasive option = $1202, cost of traditional surgical option = $3036. Value of a happy child and parent = priceless. Value to the practice of word of mouth referrals, increased new patients, increased productivity of quicker/simpler procedures, and reduced stress for me = priceless.

Jeanette MacLean, DDS, DABPD, FAAPD

Office (623) 362-1150
http://www.kidsteethandbraces.com

Images for Case Report




10/29/18
Jeanette MacLean, DDS

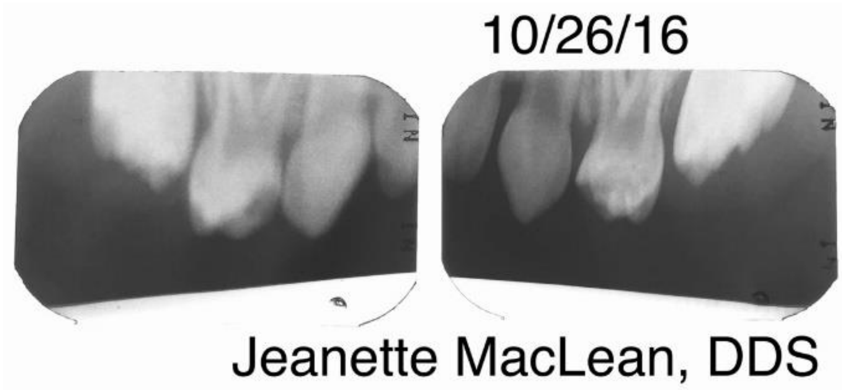

5/21/19
Jeanette MacLean,DDS

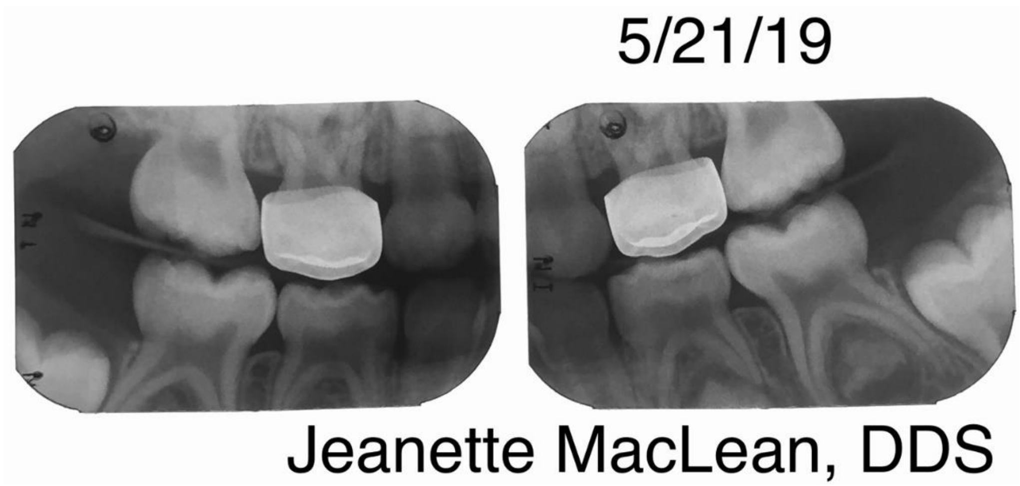

4/26/18
Jeanette MacLean,


5/21/19
Jeanette MacLean, DDS


5/21/19
Jeanette MacLean, DDS


5/21/19
Jeanette MacLean, DDS


10/26/16
Jeanette MacLean, DDS


5/21/19
Jeanette MacLean, DDS


5/21/19
Jeanette MacLean, DDS


5/21/19
Jeanette MacLean, DDS

Case Report – Prevented in-Hospital Treatment with General Anesthesia via SMART Intervention

(Dr. Steven Duffin, DDS)

Deckland was a young patient whom I first saw at about age four who presented with advanced ECC throughout his mouth and especially effecting the anterior maxillary teeth. His preliminary examination occurred in the time period when I was just beginning to learn about SDF and I was still going to the hospital regularly to treat these types of cases. Due to the long wait time for an operating suite (OR) opening in my schedule, I suggested to Deckland's parents that perhaps it would be helpful to place SDF to just slow down the decay process and possibly prevent abscess formation while we were waiting for a treatment appointment in the hospital. Shortly after placement of SDF, we observed the classic darkening and hardening of the decay. I explained that we would correct this cosmetic problem when the OR date arrived. Shortly thereafter, some change in Deckland's life circumstances resulted in his losing his Medicaid dental insurance coverage. His parents chose no further treatment and I lost track of him. Later, Deckland resurfaced with his arrested primary teeth exfoliating naturally and, finally, I was able to see him with his permanent dentition in place.

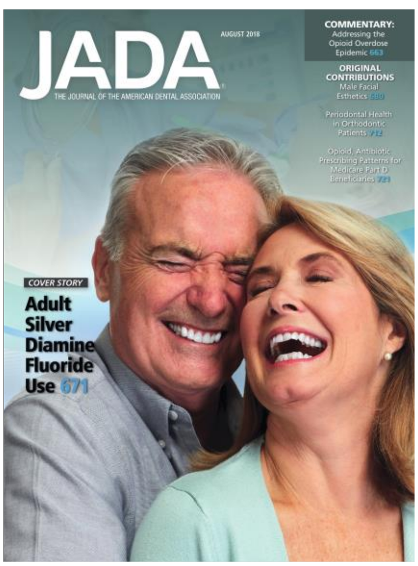
"**It is important to emphasize that there was no further treatment during this time period other than an initial intensive application of SDF and fluoride varnish**." – Dr. Steve Duffin

Deckland did not develop new decay during this period and was progressing toward a normal adult dentition. Fortunately, I had the good sense to take some photographs of this case during the time period described. I was not intentionally documenting this SDF treated case and was rather astonished by the results that were seen.

Silver Diamine Fluoride Articles in the Recent Dental Literature

(Dr. Steve Duffin, DDS)

The August 2018 cover story from the Journal of the American Dental Association is dedicated to the use of silver diamine fluoride in adults. Likewise, similar reports appear in the Journal of Dental Hygiene and in the Journal of the American Association of Pediatric Dentists. This is a very popular subject.



Policy on the Use of Silver Diamine Fluoride for Pediatric Dental Patients

Originating Council
Council on Clinical Affairs

Latest Revision
2018

Purpose
The American Academy of Pediatric Dentistry (AAPD) recognizes that dental caries continues to be a prevalent and severe disease in children. This policy addresses the use of silver diamine fluoride (SDF) as part of an ongoing caries management plan with the aim of optimizing individualized patient care consistent with the goals of a dental home. When SDF is indicated, it is essential that the infants, children, adolescents, or individuals with special health care needs receive a comprehensive dental examination, diagnosis, and plan of ongoing disease management prior to placement of the material. The dental profession has long viewed dental caries as an acute disease condition requiring surgical debridement, cavity preparation, and mechanical restoration of the tooth, but increasingly, especially for the infant and child population, practitioners are utilizing individually tailored strategies to prevent, arrest, or ameliorate the disease process based on caries risk assessment. One of these strategies employs application of SDF as an antimicrobial and remineralization agent to arrest caries lesions after diagnosis and at the direction of a responsible dentist of record.

Methods
This document was developed by the Council on Clinical Affairs and adopted in 2017. This policy is a review of current dental and medical literature and sources of recognized professional expertise and stature, including both the academic and practicing health communities, related to SDF and silver nitrate. In addition, literature searches of PubMed®/MEDLINE and Google Scholar databases were conducted using the terms: diamine silver fluoride and caries, Howe's solution, silver nitrate and caries, and silver diamine fluoride; fields: all; limits: within the last 15 years, humans, English, birth through age 99. One hundred eight articles matched these criteria. Papers for review were chosen from this list and from the references within selected articles. Expert and/or consensus opinion by experienced researchers and clinicians also was considered.

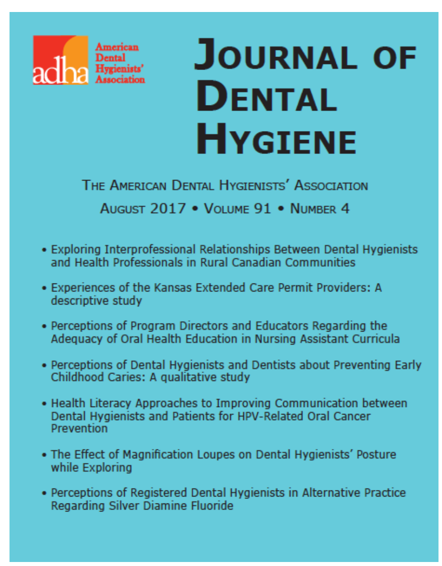
Background
Treatment of incipient caries usually involves early therapeutic intervention using topical fluoride, and non-surgical restorative techniques such as dental sealants and resin infiltration. The use and outcomes of these techniques have been well-documented, and there are current policies and guidelines with recommendations for their use in the practice of dentistry.[1-3] In contrast, treatment of caries lesions traditionally requires surgical intervention to remove diseased tooth structure followed by placement of a restorative material to restore form and function. Barriers to traditional restorative treatment (e.g., behavioral issues due to age and/or limited cooperation, access to care, financial constraints) call for other alternative caries management modalities.

Silver topical products, such as silver nitrate and SDF have been used in Japan for over 40 years to arrest caries and reduce tooth hypersensitivity in primary and permanent teeth. During the past decade, many other countries such as Australia and China have been using this compound with similar success.[4,5] As marketed in the United States, SDF is a 38 percent silver diamine fluoride which is equivalent to five percent fluoride in a colorless liquid, with a pH of 10. The exact mechanism of SDF is not understood. It is theorized that fluoride ions act mainly on the tooth structure, while silver ions, like other heavy metals, are antimicrobial. It also is theorized that SDF reacts with hydroxyapatite in an alkaline environment to form calcium fluoride (CaF_2) and silver phosphate as major reaction products. CaF_2 provides sufficient fluoride to form fluorapatite which is less soluble than hydroxyapatite in an acidic environment.[6,7] A side effect is the discoloration of demineralized or cavitated surfaces. Patients and parents should be advised regarding the black staining of the lesions associated with the application of SDF. Ideally, prior to use of SDF, parents should be shown before- and after-images of teeth treated with SDF. Recently, the Food and Drug Administration approved SDF as a device for reducing tooth sensitivity, and off-label use for arresting caries is now permissible and appropriate for patients.[8-12]

Many clinical trials have evaluated the efficacy of SDF on caries arrest and/or prevention,[6,13-18] although clinical trials have inherent bias because of the staining (i.e., since the

ABBREVIATIONS
AAPD: American Academy of Pediatric Dentistry. **CaF_2:** Calcium fluoride. **SDF:** Silver diamine fluoride.

ORAL HEALTH POLICIES 53



MMC Treatment on the Street

(Dr. Steve Duffin, DDS and Marcus Duffin, MS, MBA)

A group of MMC / SMART advocates including these authors, participated in a free sidewalk dental clinic in front of the IADR 2017 meeting in San Francisco. We were able to demonstrate that the placement of SMART restorations for people seeking free dental care was possible with minimal dental equipment needs, including no access to electricity.

We understand that this practical demonstration of SMART techniques may have caused heartburn on the part of some of our colleagues. We encourage reconsideration and remembrance of the words of Tomas Kuhn with respect to change in society found in his classic book The Structure of Scientific Revolutions published in 1962. Paradigms do tend to shift. It was an honor and privilege for me to be there.

Link to IADR 2017 video

- https://youtu.be/LxTVFGU5m0Q

Hand Drilling—A Gentle Approach

(Gerry Beauchemin, DT)

Editor comment: As we were coming to the end of editing the SMART ORAL HEALTH textbook prior to publication, I became aware of the work of Gerry Beauchemin through Dr. John Frachella. Gerry introduced me to this technique via a most interesting video conference call with colleagues in North America and Europe. Having learned some concepts about his atraumatic "hand drill" technique, I must admit that I have not yet used it clinically. Dr. Frachella on the other hand has treated many SMART cases using the hand drill as a step in the placement of SDF and GIC. His support for this approach is very enthusiastic. I felt that it is sufficiently important to add to the manuscript at the last minute. Thank you Gerry for important contribution and best wishes to all. -Dr. Steve Duffin

In 1996, I was introduced to ART, a restorative approach using hand instruments with no need of electricity, heavy bulky equipment, or scary needles and drills. It became my *modus operandi*—creating new possibilities to bring greatly needed dental care to under-served areas of the world. After a period of time practicing ART and gaining experience with it, I discovered a more effective and efficient way of gaining access to underlying caries and removing it—using dental burs glued into mirror handles. This made ART easier and more efficient for me. For two decades I have practiced this approach and have taught it to many.

Now with the Medical Management of Caries joined with ART together, coupled with all the benefits associated with hand drilling, I believe this gentle approach will help pave the way to bring SMART to developing communities throughout the world. It is my hope that what I have been privileged to learn and practice for years—as explained here, will help make learning and using this technique easier and more efficient for everyone. May we all provide gentle and painless care to all our patients. Happy drilling—the gentle way!

My deepest thanks to four dental pioneers who have greatly inspired me: Jo Frencken—for his great efforts in pioneering and promoting ART throughout the world; Martin Macintyre for discovering and teaching us the amazing effectiveness of glass ionomer sealants; Steve Duffin—for all his research, both at home and abroad, in rediscovering and introducing the medical management of caries to our generation and many to come; and John Frachella—for developing an effective application system combining SDF with glass ionomer, along with his wealth of validating experience for proving the healing and preventive powers of SMART. Finally, I thank and deeply appreciate all the contributing authors of this momentous volume for all you have done to make this textbook a reality—especially the editors.

Introduction

I am thrilled, in this chapter, to introduce hand drilling to dental care practitioners wanting to vanquish fear in their patients. Once it is mastered, an operator can access soft decay in less than a minute, sometimes in ten seconds or less, and in most cases, faster than it takes to numb the tooth. Furthermore, hand drilling helps protect the pulp, as patients provide instant feedback if the pulp is being traumatized, allowing the practitioner to stop working before causing irreparable pulp damage. And most of all, it eliminates the two greatest fears associated with dental care—injections and power drilling.

These notes are for both dental professionals and people we train to perform SMART in the developing world. I try to keep the language as simple as possible for everyone's benefit; that is why I sometimes offer explanation past what the professional might need, and use "decay" instead of "caries." Any references to patient head handling would assume the patient is in horizontal position.

To help guide the practitioner in mastering this gentle approach to accessing dental caries, I offer you the following points gleaned from experience. Even though adults love it too, gentle hand drilling is especially crucial with small children. Any experience of dental work in their mouths will affect how (and whether) they seek help for dental needs for the rest of their lives. Please wait until you have mastered hand drilling on others before attempting it on a child, especially a fearful child.

Safety and Patient Comfort

Our chief concern in hand drilling is our patient's safety, peace of mind, and comfort. This requires us to carefully follow our safety precautions and care for them with gentleness. Note the following hazards; avoid them with these precautions:

- Puncture wounds from a drill slipping. Assure your drills are well anchored *before* applying strong pressure.

- Recommended Vaccines for Healthcare Workers
    - https://www.cdc.gov/vaccines/adults/rec-vac/hcw.html

- Eye injuries from inadequate eye protection. Use *strapped* goggles on all patients.

- Pinching patient's lip between drill handle and a tooth. *Continually monitor* the lip adjacent to your drill handle.

The first thing in working with a patient is to talk to them (or their parents), to set their minds at ease about the procedure. Gently place your hand on your patient's shoulder and ask if they feel that. Then gradually and slowly press down firmly—on and off a couple times over five seconds. Tell them you will be pushing like that on their teeth with your "tooth cleaners" to remove the stuff that harms their teeth. Ask them if it is OK. They always nod yes or say, "It's OK" or "Fine." Thank them for their permission. Also, when reassuring my patients, I never say "painless" cleaners. I do not want the word "pain" or other undesirable concept entering their minds. Psychologists say that in clinical settings, a patient's brain filters out the negation part and only hears the part about pain.

Holding the Hand Drill

In this chapter, a right-handed operator is assumed for simplicity. When perforating enamel—as in a cavity, use a palm cap (a ½ inch copper plumbing cap with a dab of petroleum jelly to reduce friction). Position the drill handle in the palm cap which sits in the middle of your palm. Hold it with your thumb, index, and middle fingers. Spin the drill clockwise as opposed to back and forth rocking (which includes the wrists). Spinning clockwise is less tiring and more efficient as each motion is a cutting action.

Spinning clockwise is mandatory when perforating intact enamel as it enables the operator to keep the drill handle in perpendicular alignment. Not so with back and forth rocking. Caution: If you veer off perpendicular alignment with the #½ bur, you *will* fracture the shaft—this size is extremely fragile. When removing enamel overhangs, see “Larger Cavities.” When removing decay, use a pencil grip.

Hand Drilling Procedures

Hand drilling techniques differ when drilling intact enamel or existing cavitations and pits and whether drills contact enamel or decay only. Since I do not have access to radiographs in my context, I drill intact enamel only if I see a white chalky appearance on a well dried tooth.

Intact enamel—create a pilot hole

Intact enamel is a smooth glassy surface, largely convex, which makes it very slippery for a hand drill to initiate drilling, especially when wet. Caution must be exercised to prevent slipping and injury. Dry surface extremely well and use a dry bur. Align your drill handle perpendicular to the surface to be drilled which requires close inspection of the crown’s surface topography. Use a *new* #½ round bur for each tooth. Use a palm cap.

Position your *dry* bur tip on the *dried* surface with the handle in perpendicular alignment. Start with light pressure turning clockwise only. When you see enamel powder trickling out, **stop** and **test** to assess penetration status. Do this by applying slight pressure in all directions. If the bur tip stays in place, proceed.

Having verified that the drill has *started* to anchor itself on the surface, gradually add more and more pressure. Drilling intact enamel requires *strong* pressure; maintain perpendicular alignment at all times; drill under dry conditions. As you drill, let the power just trickle out, do not stop to clean. As long as the power keeps coming out, keep drilling till you see a large pile of powder. *Now* clean and check penetration depth. Drill until you penetrate 1½ to 2 times the diameter of your bur tip. Wear magnifiers to see more precisely. Once you have achieved this depth, you now have a pilot hole for sequential drilling to access underlying decay.

Note: This is the most difficult part of hand drilling; all other drilling is easy. In my experience in the developing world, I *rarely* drilled intact enamel. I had more than I could handle drilling simple and quick cavitated lesions and soft pits. Remember! If you fail to keep your drill handle perpendicular when initiating a pilot hole in intact enamel, it could slip off and injure your patient or yourself.

Cavitated lesions, soft pits, pilot holes—sequence drilling

Sequence drilling means drilling in increments from a smaller bur size to the next higher size. It is *very* efficient. It can take a few seconds to over a minute depending on enamel thickness, bur sharpness, and extent of pressure used. Size choices are #2, #4, #6, #8. What size we start with depends on the size of our cavity. We begin with the smallest size too large to enter the cavity. In sequence drilling, each bur is drilled to a penetration depth of 1½ to 2 times the diameter of its tip. This depth makes the next size easier and faster to penetrate. Unlike penetrating intact enamel, all other drilling is best with a wet bur and frequent rinsing. Keep a wet gauze adjacent to your tooth for wiping as needed. Keep them in water while in use and until cleaning time. This makes cleaning easier.

Efficiency in sequence drilling requires strong pressure with clockwise rotation using a palm cap. Do not startle or alarm your patients by suddenly applying strong pressure. Apply pressure very gradually in the beginning until your patients adjust to “pressure” dentistry and realize that it causes no discomfort. Once they adapt to it, you can apply high pressures sooner on subsequent lesions. Drilling with strong pressure also requires counter-pressure for patient comfort. On the mandible, counter pressure is exerted under the mandible with the left hand. On the maxilla, it can be applied in various ways according to treatment positions, with a hand, one’s torso or thigh if standing.

Dr. John Frachella, who mostly treats phobic children, prefers a twisting back-and-forth motion of the hand drill between thumb and forefinger. He finds it more effective in removing un-mineralized dentin. He says, “Repeatedly twisting a hand drill with a new, sharp round bur a quarter rotation to the right, then a quarter to the left draws un-remineralizable material from lesions much more effectively than a slow-speed handpiece’s unidirectional rotary drilling with a round bur.”

It is crucial to use extremely sharp burs for excavation, where patient sensitivity is a critical factor. This enables us to remove soft decay with a feather touch—the weight of the instrument. This gives consistently painless results. Now, thanks to SMART, it is no longer necessary to excavate close to the pulp.

Larger cavities

There are a number of ways to open a cavity orifice that is wider than a #8 diameter. Grip your drill in your hand (or use a pen grasp) and add finger pressure on the bur shaft with your left hand; or grasp your drill with your right hand placing your index finger on top to exert downward pressure (for extra pressure add your left index finger over your right index finger). Apply quick snapping motions. The #2 and #4 chip enamel easier than larger sizes. Use #6 on thin enamel. Once the opening is enlarged, remove soft “mushy” decay by scraping circumferentially (as Dr. Frachella teaches) using a sharp #6 or #8.

Procedural Tips

- Do not cross the midline by drilling on a tooth from the opposite side of the mouth unless it is a lingual or palatal lesion. You cannot align your drill handle properly that way.

- I prefer thin mirror handles when I want to maximize visibility in distal areas on adults, especially in smaller mouths.
- If you diagnose caries with an explorer, you can prep soft pits immediately with hand drills to save time.

- For difficult to access (i.e., tight) third molars: Keep the mouth only half open for better access. Assure that your bur is well anchored. You can proceed by feel without visual reference. Watch that the drill handle does not pinch the lip.

- Hand Drilling Demo Video
    - https://dentalcareforall.org/

Example of a demonstration model.

Hand Drill Fabrication and Maintenance

- Hand drills are made by gluing a dental bur into a mirror handle. I use J-B Weld Original Cold-Weld Steel Reinforced Epoxy. It can withstand temperatures of 550° F when fully cured—great for autoclaving. I use sizes #½, #2, #4, #6, #8 round carbide burs, HP type (HP: for straight handpiece) with standard 44 mm shank. You must use "cone socket" (CS) mirror handles, as the simple stem diameter is too small for LA or HP burs.

- Dull burs can be removed by heating the shaft until the epoxy loosens. In the bush I have removed them by heating over a candle using pliers. Once cooled, use the used bur tip to scrape out the debris inside the handle before discarding it.

- After sterilization, I test burs for sharpness by gently scraping them against a plastic spatula—the one I use to mix GIC. A fool-proof way to test sharpness is to compare a brand-new bur with the one you want to assess.

- While still wet, before sterilization, clean bur tips meticulously. I use an extra hard modified toothbrush. I trim its bristles with a sharp blade to ⅛ - ¼ inch for stiffness. I do not like a wire brush; they corrode and I think, accelerate dulling.

Managing a Fearful Child

Lessons from the bush with "Little Sally"

On the initial visit:

- See Sally in the waiting area. Wear normal clothes and no mask. In a small bag, bring plastic mouth mirrors, toothbrushes, and a hand-held light.

- Become Sally's friend, that is the goal. It does not matter if that is all you do right now.

- Allow ample time; it's about building trust.

- Never mention pain to Sally, advise her parents the same.

- Sit down near Sally with an empty seat between you. Sally is on her mom's lap.

- Talk with everyone in the room while staying seated. Do not stand, you are one of them.

- Briefly explain to Sally's mom what you are about to do and why.

- While seated, demonstrate toothbrushing to all present. Then, ask one person at a time, to come and sit between you and Sally. Sally will be watching. Brush each person's teeth. Make it fun! Smile. Laugh a lot! Do not be rushed.

- Finally, scoot over and brush mom's teeth. Take a full minute.

- Now that Sally feels comfortable with you by her side all this time—you are no longer a stranger, especially since you just brushed everyone's teeth including mom's. Everyone likes you and they seem happy.

- Finally, ask mom to brush Sally's teeth first. Then you do it. If she lets you, continue brushing for 20 seconds. If she refuses, ask mom to brush her again for 15 seconds. Then try again. If she still resists, stop there and reschedule.

- Instruct mom to brush Sally's teeth 3 times a day until your next visit.

- At the next visit: sit by them again, while mom brushes Sally for 15 seconds. Now you do it. If she continues to resist, let mom do it, then try again; if she still refuses, why not get your MMC tray and let mom apply it under your direction. Her hands become yours. I do this with fluoride varnish and it works wonderfully.

On the second visit:

Assuming that Sally has allowed you to brush her teeth, you can move on to screening and treatment. Here are some tips for making this work well:

- I prefer a hand-held light over a headlamp for non-clinic screenings—it is less-scary and easier to direct your light-beam, especially if bending down in awkward positions. Be careful to not shine your light in Sally's eyes.

- Have small children sit on mom's lap while they lean back in yours as you screen and work.

- Work gently with lightning speed; time is **not** your friend.

- Make your visit short and painless (5-8 min) so she will want to return. Do whatever you can in that short window.

- Stop as soon as she fidgets—that is your cue that she has had enough for that appointment.

- If you are pressured to complete her treatment then, stop—take a break. See your next patient. Then return to Sally.

- Don't do anything detrimental to Sally's psychological well-being.

- When I am treating a small child, I do not permit other children in the waiting area. I never know if a small child may cry. I take no chances. I do not ever want a child in my clinic to hear another child crying while receiving dental care.

Reports From the Field

Here are a few quotes from others who have adopted hand drilling in dental care:

"My colleague and friend Gerry Beauchemin, a Dental Therapist, told me about his hand drills for use in ART some years ago. I thought that I didn't need these because I have access to rotary drills. So, I ignored Gerry's suggestion to try them. Some years later, my colleague Dr. Thierry Boulanger from Brussels heard about Gerry's hand drills and made some in his workshop to try them on patients. Afterwards, he contacted me saying that he found them particularly useful in the SMART protocol. I decided to make some and try them for myself. I have not used a rotary drill on a handpiece since. Plus, since I mostly treat phobic children, the hand drills dispel apprehension and frank horror of handpiece sounds and appearances. The hand drilling procedure is pain-free - a real advantage for treating kids the way I do without local anesthesia, sedation or general anesthesia. I'm not throwing away my handpieces but I am using hand drills almost exclusively for routine SMART restorations as well as for achieving open access and biofilm removal from lesions for better outcomes with SDF application. For ART, SMART and SDF-only, hand drills are faster and more effective for me and less intimidating to my patients."—Dr. John Frachella, DDS. Maine.

"In a discussion group about child-friendly dentistry, I read something that I found amazing. Gerry Beauchemin proposed to glue drills to mirror handles to make hand-drills able to access cavities without the noise and vibrations of the handpiece. So I, secured a mirror handle in a vice, put some glue and stuck a carbide bur in. I made some with different diameters. Children accept them easily and I feel more comfortable than with other hand opening instruments. Access can be made on the occlusal as well as on the proximal. Carious tissue can then be excavated either with these drills or an excavator. Ideal for SMART restorations." —Dr. Thierry Boulanger, DDS. Belgium.

"Gerry Beauchemin taught me the method of using burs in mirror handles to hand drill decayed teeth in order to place a glass ionomer restoration. The burs are easily replaced when they get dull. I am able to cut through hard enamel to enable me to get to the decay. No heat is generated, therefore there is no discomfort for the patient unless I am getting close to the nerve. By watching the patient's facial expressions and body language I am able to back away from a sensitive area before any real discomfort occurs. This allows me to earn trust with my patient and create a good relationship when I don't even speak their language. I am not a licensed dentist, I am a certified dental assistant. I was able to learn using this method very quickly, a matter of hours. I have assisted dentists using high speed handpieces that generate heat, requiring the tooth to be constantly sprayed with water to cool it. This spreads debris all over the patient's mouth and possibly down their throat, requiring an assistant to be constantly suctioning and a very uncomfortable patient. A lot of noise, water spray, and two people in their mouth with instruments. With Gerry's bur drilling technique there is no noise, debris is contained and easily cleaned away with cotton and only two hands in their mouth, not four. A much better experience for the patient. Of course doing the procedure by hand versus machine takes a little longer. However, having a happy patient with a good result is worth the extra time."—Janet Danner, Certified Dental Assistant. Virginia

"My wife and I went to Texas so that I could meet Gerry and review the process. I became convinced that his techniques were easily learned and performed. The highest priority was given to quality treatment, patient comfort and sterility.

We became active associates of Gerry and his efforts to train others. Doing missions in over 10 countries (some several times). Gerry has continued to refine his course by always being inventive and innovative. Much of Gerry's teaching involved use of "hand drills" which are made by the students. Thus inexpensive and easily replaced. The technique uses small round burs and slow, but firm pressure to open up the cavity and remove decay painlessly. Decay can be carefully removed circumferentially until all or most all decay is removed. It is a slower process than using a dental handpiece; but if you factor in that no anesthetic is needed, and there's no pain to the patient, it is worth it. An important additional "plus" is being able to carry everything in a backpack. All this to say that it is possible to do dentistry in remote places or even in an office setting using a gentle simple "hand drilling" technique. This avoids anesthesia and the scary/noisy dental handpiece and the equipment to power it. Believe me it works!" —Dee J. Danner, DDS. Virginia.

"We learned a new technique that Gerry had developed, using a twist of the wrist with dental burs set in mirror mounts. There were no harsh movements and no extreme force. With a #2 bur we could make precise, gentle excavations, and if the caries were deep a quick succession through #4, #6, and #8 would see us quickly and easily through. By the second day of lab practice we could work through the entire succession in a minute. Our first and most tentative work was slow, but as our skill and confidence grew we could apply a little more pressure and work much more efficiently. This gradient of skill was different than the binary of using the hatchet—you either cracked off a piece of enamel, or did nothing.

Literally days after the class ended I was seeing my own patients in a makeshift dental clinic on the other side of the world. I used the drills almost exclusively. In the first week or so I used the hatchet a couple of times, but as I gained proficiency with the drills I quickly found that I didn't need the hatchet. There was no decay that I couldn't reach with them. It was always much easier and faster to use the drills than the hatchet so I could treat more people, and it was much more comfortable for the patients. Gerry had taught us to watch our patients' eyes as a key indicator of their comfort. In the first couple days I was working, I had an 8-year-old patient who kept closing his eyes, and I thought he was miserable. I felt bad and did my best to be gentle and kind, and of course I chose to use the drills exclusively for him. Eventually his eyes closed and his mouth went completely limp... and I realized his eyes were closing because he was falling asleep! I blocked his mouth open to complete the filling, then woke him up to go play. I was stunned—less than two weeks previously I had absolutely no dental training at all, and here I was excavating teeth and placing fillings. Moreover, my patients not only had no need for anesthetic but could literally be lulled to sleep by the work! To this day it feels like pure magic." —Jason Padvorac, BS, Biomedical Engineering. Washington.

Pure Magic

Jason Padvorac calls hand drilling "pure magic." I agree—see for yourself. Just be patient like he was, because there is a learning curve. Please master this on confident patients before attempting it on fearful ones, especially on fearful children. But, although hand drilling may *seem* complicated at first, it **is** easy. I've done it a long time and trained many in it. Any questions? Email or call me.

Happy Drilling—the Gentle Way!

Gerry Beauchemin
gerry@dentalcareforall.org (1) 956 280 1708

MMC Project in Ecuador

(Dr. Steve Duffin, DDS and Marcus Duffin, MS, MBA)

Image courtesy of Dr. Steve Duffin.

In mid-2014 a dentist from Ibarra, Ecuador contacted our dental office in Oregon after reading my paper in the 2012 CDA Journal about the medical management of caries (Duffin S, Back to the Future, The Medical Management of Caries: Introduction, CDA November 2012). We discovered that severe early childhood caries is a significant problem in Ecuador. This eventually led to a visit by the two lead dentists from the Ecuador Ministry of Health to my Shoreview Dental clinic in late 2014.

They observed treatment in the clinic, shared more information about the situation in Ecuador and we collectively decided to conduct a demonstration program using silver nitrate and fluoride varnish in a rural school near Ibarra " Escuela Galapagos". A manual was developed with the assistance of Kelly Matthews, RDH and our team traveled to Ibarra in March of 2015 to conduct the project. Our role was to act as advisors to the Ecuadorian Ministry of Health dentists. We saw 165 children at the Galapagos school and 40 children at the school for children with disabilities associated with the municipal hospital in Ibarra.

Galápagos school in the mountains above Ibarra, Ecuador

After this initial outreach effort our team returned to Ibarra at 3, 6 and 12 months to collect outcomes data.

An Interview with the Director of Disabilities School was conducted while treatment was being provided to the children and is available for viewing at:

- https://vimeo.com/276312856/82261ec716

Careful data collection at disabilities school in Ibarra

Ecuador Perspective of a Dental Hygienist

(Jonalee Potter, MHA, BSDH, RDH, EPP)

Jonalee Potter RDH, MS.

The NoDK (no - decay) Team set out to treat tooth decay, January 2016, in Ibarra, Ecuador. One team member went to Ibarra to meet local team members, start the paperwork and make charts.

The participants were students in two different schools; a special needs school and an elementary school set in the mountains outside of Ibarra. The ages were between 4 and 19 years old and all had tooth decay.

The special needs school was the destination for my first trip with the NoDK team. There I met the on-staff dentist, his assistant and the children we were treating. The students ranged in age from four to 19 years. All the children in this school had disabilities that ranged from minor to major. All had tooth decay, some were in pain and all needed treatment with 25% Silver Nitrate and 5% Sodium Fluoride Varnish.

Let me take you back a few years and give you my learning and understanding of Silver Nitrate and Fluoride Varnish. When I started working with Dr. Duffin he introduced silver nitrate and fluoride varnish to treat tooth decay. He told me the history of silver nitrate treatment, the scientific reasoning and the expected outcomes. Patients were to have three applications two to three weeks apart. He was also treating patients in assisted living, memory care, homes, etc. as they couldn't get out to see a dentist. I would make these visits with him, witnessed the procedure and on a return visit, saw the outcome.

The results were amazing. On the second application visit the decayed areas were light brown and this color was the way to determine the bacteria, causing the cavity, was dying. Exploring the area was avoided as not to break down the area of decay. The third visit the expected outcome was to have a black "scar" and be hard to exploring. If the areas were hard, on the third visit, a three-month reevaluation appointment would be established. On any subsequent appointments, the areas were explored and if there were any areas of softness the tooth/teeth would be retreated.

Further treatment with glass ionomer cement for the decayed areas can be done to prevent food impaction into a "hole" and/or an opaquer can be applied to the black "scars" to improve the appearance. These procedures can be done without anesthetic and thus keeps the traumatic experiences minimal. This atraumatic treatment for tooth decay has great outcomes and keeps patient's experiences positive.

NoDK Ecuador team.

The silver nitrate/fluoride treatment protocol worked great for this population of children. With most of them having numerous areas of decay, the need to keep treatment atraumatic, treat all areas during one visit and have them cooperate this was the best treatment. The teachers brought the students to an office, line them up, treat the teeth while they sat at a desk, charted and dismissed. Most of the kids were very cooperative and we saw approximately 50 to 75 kids in a half day.

Our supplies included a bottle of silver nitrate, dappen dishes, single dose packets of 5% sodium fluoride varnish, mouth mirrors, gloves, etc. For drying the teeth (gives the best results) we used a garden sprayer with an air/water syringe tip. The sprayer could be pumped up with air and on using the trigger switch it would move the air through the tip and directed on the tooth. These supplies allowed a provider to work on their own, away from a dental office thus making it convenient for care and the ability to treat many in one area.

While I was helping the children in the special needs school the other team members were helping children in the mountains above Ibarra. These children and their families lived, farmed, and attended school in this remote area. Most of these children walked or rode horses to/from school and access to medical/dental care was difficult.

The school program ran simultaneously to the special needs school. Both groups were treated the same. The same treatment, same products, and the same protocol. The number of children seen at the school ranged from 75 to 100.

The children in both groups had tooth decay and many were complaining of mouth pain. Our team goals were to treat their tooth decay and to stop the mouth pain. The children were taught proper toothbrushing, the importance of good homecare and some nutritional counseling. The treatment supplies and protocol were the same between the special needs school and the elementary school. Both teams included local dentists, school staff and us. All were trained to be a part of the team. Continuity of care was done by the local dentists and school staff during our absence.

Our team returned three months from our first trip to collect data and to apply another round of silver nitrate and fluoride varnish. In collecting data the children who were having pain in the beginning were no longer having pain. Homecare and understanding the importance was much improved. The decayed areas had “black scars” and the tooth structure was hard. Areas of decay that were “holes” food traps were filled in with GIC to prevent the possibility of future decay. The outcomes were terrific.

The care continued while we were home and Dr. Duffin was to make the follow up trip at the one-year anniversary. On his return he found the silver nitrate and fluoride varnish treatments to be successful.

The children were still pain free and the previous decay arrested. A success story for the children in the special needs school and the elementary school on the mountain side above Ibarra.

Ministry of Health dentist examinations.

My trips to Ecuador further proved to me that the atraumatic treatment of tooth decay is successful. The use of silver nitrate and fluoride varnish was the successful treatment combination. The children were pain free and their tooth decay was successfully treated in a non-invasive atraumatic procedure. Knowing these kids will be followed up with the local dentists and school staff is reassuring.

This trip and being a member of the NoDK team has left a special place in my heart. I was proud of our work and happy to see the children go from pain to comfort. Proud to see decay arrested and "black scars" present. I am also reassured as they will receive follow up care to help in maintaining better oral health.

Silver Nitrate was used for this trip but now the treatment of choice is Silver Diamine Fluoride. The five percent fluoride varnish continues to be the same.

MMC Project in Ghana

(Dr. Steve Duffin, DDS and Marcus Duffin, MS, MBA)

Following the success of our MMC demonstration project in Ecuador, I knew that we needed to repeat this project in another part of the world. This led to an invitation to visit Ghana from The Honorable Nene Duneno the $1^{st,}$ Phillip Kradolfer. Philippe is a swiss citizen who lived in Ghana and has been named an honorary chief there.

Phillip arranged for us to provide care for 300 children in the remote village of Kpetoe, Ghana. This opportunity was of particular interest to me because there are only 250 dentists caring for a population of 27 million people in Ghana. This would be an opportunity to show how the MMC

Nene Duneno the 1^{st}.

principles could extend oral health care to remote and underserved populations.

In September of 2015 our team went to Ghana where we reproduced the same protocols that were conducted in Ecuador. Happily, we found that the children in rural Ghana had far fewer cavities than their counterparts in Ecuador. This difference presents an opportunity for future research.

Initial school exam.

Very few cavities!

Joanne Duffin with a friend.

We returned at 6 and 12 months to collect outcomes data from this population using our standardized charting system.

Charts ready to go!

Hailey Taylor 3rd year UCSF dental student.

Salivary sample collection.

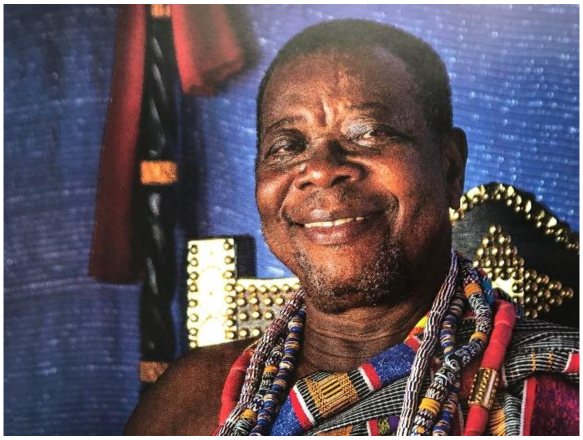
Toothbrushes for all!

Salivary samples of oral bacteria from children with and without tooth decay were collected in order to examine the oral microbiota in this population.

These samples were placed in stable storage media and transferred to the University of California at San Francisco for processing using 16S RNA analysis.

This aspect of our program received IRB approval from the University of California at San Francisco.

Special thanks are offered to the Paramount Chief His Honor Nene Nuer Keteku III, for granting us permission to provide this service to the children of Kpetoe. The Paramount Chief of the Kpetoe region, Nene Nuer Ketku III gave us permission to provide care to the children in this region. We are grateful for the assistance of Dr. Ama Ofosu Appiah, a Ghanaian dentist who received her dental training at the University of Michigan, practiced in Detroit for 20 years, before returning to her homeland to serve the people waiting there for her.



Nene Nuer Keteku III

Dr. Ama Ofosu Appiah

Another special thank you to Veronica Sadah, Proprietress of the Comfort Betroh Memorial School in Kpetoe, Ghana, for her kindness in support of our teams and cooperation with her school and community.

Proprietress (headmistress) Veronica Sadah and Dr. Steve Duffin.

We interviewed the Proprietress, Veronica Sadah to learn more of her personal motivation for starting the Kpetoe school and we are happy to share her story with you.

- https://www.youtube.com/watch?v=HJNR--NnlQA&t=11s

Ghana Perspective of a Dental Hygienist

(Jacqueline Juhl, RDH, BS, MS)

Joyful Kpetoe School with Dr. Ofusu-Appiah and team

Introduction

"Do not look where the harvest is plentiful, but where the people are kind." -African proverb (*Kradolfer, 2015*)

Beautiful, generous, and proud, Ghana is like her people. As a Washington State Registered Dental Hygienist, participating in Medical Management of Caries September 2016 Ghanaian cultural and scientific experience was a great privilege. To serve in the company of visionary oral health providers proved both an invaluable professional opportunity and personal milestone. Encountering Ghana's amazingly open and generous people in the context of this unique journey proved a profound experience indeed. Further, participating in medical management of [tooth decay or cavities in teeth called] caries clinical research also provided an opportunity to discover additional evidence of the value of dental hygienists in field-based oral health research, hopefully, for the benefit of those most in need.

Background

Purpose and the old "new" addition to the caries treatment arsenal

"If we stand tall it is because we stand on the backs of those who came before us." -Yoruba proverb (*Kradolfer, 2015*)

The purpose of the Ghana trip was two-fold. The team came to Ghana as invited guests of a remarkable acquaintance of Dr. Duffin, a Swiss-Bolivian who is a regional Tribal chief or "Nene". His political power and savvy, love of his adopted people, and magnanimous generosity and hospitality were critical to achieving the team's goals. He had invited Dr. Duffin and team to again attend the Kente Festival held in the Agotime region in the south eastern part of the country, near a small town, Kpetoe. Kpetoe was the site of a school of about 300 elementary children, many of whom had received a Medical Management of Caries treatment protocol and participated in data collection in 2015. The second purpose of the Ghana journey was to collect follow-up data from this same sample, critical to further expanding our knowledge of silver nitrate's full potential in managing caries. To accomplish the data collection, any treatment of any Ghanaian citizens, including children, was accomplished with the obtained permission of the Paramount Chief, the children's parents, and the Ghanaian Minister of Health and, additionally, conducted with the oversight of a Ghanaian dentist. She was our local champion, a brilliant and dedicated Ghanaian dentist educated at the University of Michigan School of Dentistry, who practiced in a hospital in the capitol city of Accra. She had facilitated and worked with the initial 2015 MMC Ghanaian experience and functioned not only as a clinician but a local informant, liaison, and a well-spring of Ghanaian customs, history, and much more. Her gracious hospitality and generous support of time, resources, clinical skills, and commitment to the welfare of her nation, proved invaluable to the success of the team's efforts.

Much of what is known about MMC, its history, pharmaceutical efficacy, chemical properties, rationale, and the clinical application techniques of MMC have been discussed elsewhere in this text. The cumulative scientific evidence and recent FDA clearance to market of SDF as a fluoride treatment and desensitizing agent can now enable cost-effective arrest and prevention of caries infections by dental hygienists who apply MMC which possesses germicidal and substantive properties in addition to causing tooth remineralization(*Mei, Lo, & Chu, 2016)* (*Horst & Heima, 2019*) (*"Search of: silver diamine fluoride - List Results - ClinicalTrials.gov," 2019*) (*Duffin, 2012*) (*"Do's and dont's of silver diamine fluoride," 2016*).

The professional dental hygiene implications for MMC, a "rediscovered" medicament, are indeed vast. Why? The International Federation of Dental Hygienists defines a dental hygienist as a "health professional" who… "seeks to prevent oral diseases, provides treatment for existing disease, and assists people in maintaining an optimum level of oral health. Dental hygienists are health professionals whose primary concern is the promotion of total health through the prevention of disease…."(*"IFDH - International Federation of Dental Hygienists. Preventive Oral Health," 2016*). The American Dental Hygienists' Association defines a dental hygienist as a licensed oral health care co-therapist whose work compliments care provided by dentists and who specializes in the "…recognition, prevention, and treatment of oral diseases and conditions." (*American Dental Association, 2012*) (*American Dental Association, 2016*) As such, dental hygienists serve in many settings and varying conditions often providing the only oral healthcare for our planet's poorest and most vulnerable and disenfranchised. Having studied the MMC literature, worked with the actual material in a school setting in Ghana, and witnessed its efficacy resulting from previous treatment of the same school children, this author (J.J.) is convinced of its limitless potential for sparing global populations of varying ages from the ravages of caries, a preventable infectious disease. In 2015, researchers reported that dental disease costs this planet $442 billion USD per year, $2.29 billion of that attributable to Sub-Sahara Africa, including Ghana (*Listl, Galloway, Mossey, & Marcenes, 2015*). In the hands of dental hygienists globally, the legal ability to make evidence-based case selections for the application of MMC, and the healthcare delivery mechanisms and resources enabling such, could potentially spare millions trauma, suffering, avoidable treatment risks, and billions of healthcare resources.

Ghana History and Health Care Delivery

“Look to the past to help move up toward the future” -Ghanaian proverb (*Kradolfer, 2015*)

Thoroughly studying all one can prior to arrival in a new country was an important lesson that the author’s previous experiences serving abroad had taught her. Such preparation facilitates broader understanding of the country, in this case, Ghana, and her people and potentially enhances the practitioner’s clinical and interprofessional and interpersonal efficacy. For example, knowledge of Ghana’s history and customs provides significant insight to its current healthcare delivery, including oral healthcare. Knowledge of a country’s social customs prevent unintended insults, or worse, illegal acts, which impair interpersonal communications and, in turn, negatively impact data collection, treatment delivery quality, or encounter objectives.

Located above the concavity of the Gulf of Guinea on Africa’s west coast, human settlements in Ghana began as early as 4000 BC (*“History of Ghana,” 2011*). This ancient heritage is still evident in her people’s dignity and pride. From the richness of the land itself, following empires ascended and declined but gave rise to six existing ethnic groups and the development of seven local languages with English as the official language (*Africa Guide, 2017*). Early Europeans, first the Portuguese, then Dutch, Danes, Norwegians, Swedes, and English all left their marks, not all of which were positive, especially during the exploitive colonial period from 1471 to 1947 (*Gocking, 2005*). Compounding her post-colonial cultural trauma and surviving years of corrupt independent governments, Ghana today is a struggling but optimistic democracy (*“Regional Office for Africa,” 2009*). It is one of the most stable, peaceful, and progressive nations in Africa today. In 2009, the World Health Organization Regional Office on Africa reported that improved Ghanaian economic growth still evaded most citizens due to interpersonal, regional, ethnic, and “gender” disparities (*“Regional Office for Africa,” 2009*). World Bank 2015 data reported Ghanaian per capita income as $4,080 USD compared to the United States ($57,540 USD) (*World Bank, 2015*). Despite recent economic gains, many urgent needs including improved infra-structure such as navigable roads, access to electrical and other power, food security, fuel security, basic health care, and clean water remain. Prioritization of oral health suffers in a country where a quarter of children under five die from diarrhea due to lack of sanitation and access to clean drinking water (*“Ghana’s Water Crisis - Ghana’s Water In 2019 | Water.org,” n.d.*).

Healthcare delivery in Ghana is a five-tiered system primarily funded (45-55%) by the government and foreign donors (25-35%) (*“The State of Healthcare Delivery in Ghana,” n.d.*). In his 2006 report, The State of Healthcare Delivery in Ghana, then Minister of Health, Bampoe, does not even mention oral health care delivery. Donkor posited that a mere 250 dentists served Ghana’s 27 million people, 70% of which are in the two largest cities and further noted that many Ghanaians regularly rely on tradition cures and quackery (*Donkor, 2006*). Ghana has only one dental school whose graduates typically remain in its metropolitan areas. There are virtually no dentists who maintain established practices in the rural areas. One of the five dental students who graduate each year from the University of Ghana Dental School pursue practice opportunities outside of the country.

During this author's time in Ghana, conversations with local dentists revealed that the University of Ghana School of Dentistry graduates only five dentists per year. Some of these individuals then leave Ghana for more profitable positions abroad (*"The State of Healthcare Delivery in Ghana," n.d.*). Currently, dental hygiene education and credentialing is achieved through a preceptorship and successful completion of an examination before receiving a higher designation of "oral specialist". Oral specialists achieve an equivalent of a baccalaureate degree and a license but primarily practice at the dental school. More formalized and standardized education and expanded utilization of this potentially cost-effective workforce are not currently being considered.

Dr. Ofusu Appiaah's preceptor hygienist, Antionette hard at work in Accra.

Dental Hygienist as a Member of the Research Team

"Everyone smiles in the same language."
-African proverb

The "R" in "research" stands for "rigor", specifically, "academic rigor". Research is hard work but can be deeply gratifying for those with a sincere desire to help end needless suffering and improve the human condition. However, to help assure that the "rigor" is purposeful and productive, one of the first tenants of successful research is to assemble the right research team. Working in research can be something which seems esoteric ,to some dental hygienists or uninteresting to others, but nothing could be further from the facts. As a historically "newer" healthcare profession, dental hygienists have based much of their education methodologies and content on the works of other disciplines, principally dentistry, nursing, and medicine. Nathe posits that to truly advance the dental

UCSF dental student Hailey Taylor collecting saliva samples.

hygiene profession, quality research must also be conducted by dental hygienists for dental hygienists and reflect our own unique skill set (*"Dental care is a human right that has evaded many African nations for decades," 2011*). It is therefore crucial that dental hygienists achieve the academic skills and scholarship which prepares them to conduct academically rigorous research, disseminate results of such research throughout the scientific community, and ultimately result in greater equity in oral healthcare access and improved patient outcomes.

It is also important for the research dental hygienist working abroad to understand, without personal bias, that in countries where educational opportunities are so limited and oral health needs so great, many levels of healthcare workers are needed. When education and resources are so limited, preventive and minimally invasive oral health strategies are critical (*"Advancing dental public health and dental hygiene research," n.d.*). Werner stated that "there is a strong need to… provide ordinary people and community workers with more skills to prevent and cure problems in the mouth."

Working abroad is an excellent opportunity to conduct Community-Based Participatory Research (CBPR) to address community issues such as chronic diseases or conditions. This type of research serves as a bridge of knowledge between researchers, healthcare providers, and community members (*Dickson et al., 2015*). In Ghana, as in many other developing countries, dental hygienists might work with local governments in several capacities described by the American Dental Hygienists' Association, one of the most important being the oral health educator of community health workers or the actual community directly (*Community-based participatory research : assessing the evidence, 2004*). Directly providing preventive oral health education to students, teachers, and community members was one of the most gratifying roles in which this author served during the Ghana experience. For example, whether providing culturally appropriate basic oral hygiene instructions to one-hundred Togolese parents or convincing a six-year old Ghanaian girl to trade the author's new freshwater bottle for her plastic sack of sugary orange "Calipoo" drink for the sake of her oral health, or propagating evidence-based oral health skills and

Welcoming Togolese rural community: Site of "spontaneous" dental clinic and oral health education.

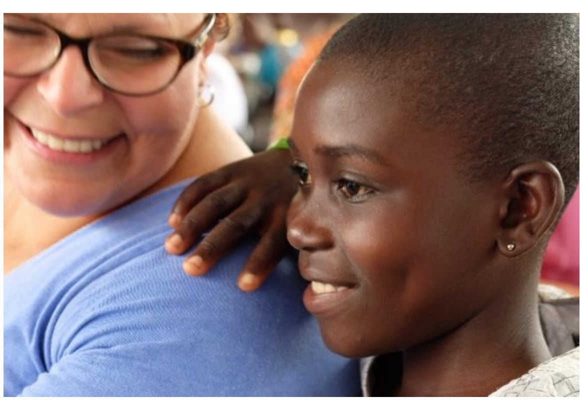
information are the professional responsibility of the dental hygienist researcher, when opportunities present.

The Ghana team consisted of Dr. Duffin's office manager who served as a logistics "veteran"; who provided invaluable extra-hands and proved herself an outstanding good-will ambassador; a second dentist, Dr. Duffin's brother, who provided clinical skills and welcomed sense of humor; an extremely capable and highly motivated second year University of California at San Francisco (UCSF) dental student who was responsible for the actual saliva specimen collection as part of Dr. Duffin's collaborative work with that institution; and this author, a registered dental hygienist of forty-two years with cumulative expertise in clinical nutrition, dental hygiene education, instructional design, dental public health, dental clinical research, and a passion for research and experience in global oral health who always travels abroad with her portable oral health education materials. Data and specimen collection, research design, and medicament applications were conducted with UCSF IRB (Institutional Review Board) approval. The basic research design of the team's efforts in Ghana is best described as an example of translational research because it was patient-focused, using an innovative intervention and direct application of modalities potentially beneficial to patient participants. Such research is called translational research because of its bi-directional "translation" from one type of research, for example, clinical research, to another, for example, CBPR (*American Dental Association, 2016*).

To fully participate and contribute substantively to any research, translational or other, success as a dental hygiene researcher and part of the research team requires a specialized academic and personal skill set. Based on lessons learned serving in Ghana and elsewhere abroad, the following skills may be the most critical of these attributes and skills. The most important of these is "**Openness**" defined as an element of critical thinking skills or an ability to challenge one's belief schema. Openness enables new learning. Learning itself is the alternation of our present schema and the construction of new ones. It is the antidote for judgmental thinking and misconception. Working in a country like Ghana, very different from what readers of this text may have yet to encounter, one could not be effective in the roles in which healthcare providers serve: clinician, researcher, educator, health promoter, advocate, or communicator without openness. Perception of what clinically or otherwise is "right" or "wrong" is based on factors specific to the given situation and relates to the openness with which the situation is fully understood. For example, without openness to local cultural mores, palpating the head of an elder might offer insult. Being open to resolving examining the elder by substituting a clinically qualified but culturally appropriate surrogate might yet achieve the needed examination data.

Openness has two great allies: **Cultural Competency** and **Emotional Intelligence.** Cultural competence is a way of recognizing one's own cultural identity and understanding the uniqueness of that of others. It can be a way of celebrating individual and population differences and a way of exploring similarities (*"Advancing dental public health and dental hygiene research," n.d.*). Recognizing, accepting, or honoring special traits within a group are reflections of our humanity, openness, and mutual respect. This is especially important when working in countries like Ghana who have experienced unconscionable harm and exploitation by foreign powers. Such collective harm has been described as cultural trauma**.** Cultural trauma occurs when a group collectively experiences some form of suffering, horrific act of inhumanity either in the past or present and include that experience in their cultural, social, or national identity (*Dickson et al., 2015*). Local individuals may express suspicion or resistance to services, information, or even contact with well-intended researchers, especially medical and dental treatments. For example, when the team was obtaining parental permission to collect saliva samples from the children at the Kpetoe school, parental consent was sought. Four parents arrived at the school wanting to know more about the data collection, application of the silver nitrate and fluoride varnish. Two children had been diagnosed with abscessed teeth and needed extractions. Despite providing thorough informed consent to all parents by our Ghanaian dentist, Dr. Ofosu-Appiah, two parents refused to allow their children to be treated with extractions or to participate in sample collection or application of any medicaments and did so with much apparent emotion. Such response might be interpreted as possibly based in cultural trauma.

Amazingly, despite Ghana's traumatic history at the hands of many foreigners, the warmth, generosity, and appreciation with which this team was treated at every encounter attested to the indominable beauty and strength of Ghana's people.



The author's new friend, beautiful 12-year old Emmanuella.

The second great ally to openness is **Emotional Intelligence**. Caruso, and Salavoy described the concept of emotional intelligence as one which allows us to assess how well we manage our own emotions and how well we understand and can influence the emotions of others, for better or worse (*Rubio et al., 2010*). Such awareness can influence interactions not only within the research team, but those populations with whom the team is working, either as individuals or patients.

Another essential attribute for the dental hygiene researcher is **Professional Expertise**. Here, professional expertise refers to the summative practice of dental hygiene as researcher, clinician, health promoter, educator, and advocate (for those served as well as for the research team and its goals). Simply stated, it means employing the sum of one's dental hygiene education and skills at an advanced level. As an educator and speaker, the author has encountered new hygienists eager to work abroad. Without years of experience, quality clinical care and decisions, or substantive contributions to the research goals are, at best, challenging. The author has witnessed the frustration, disappointment, clinical and research errors, and loss of valuable resources resulting from participation of research team members who lack the necessary experience and personal attributes and skills. For example, while working in the South Pacific, an inexperienced research team member left because she could not tolerate the difficult work conditions of the research site. Her absence resulted in inconsistent and potentially comprised data, workload disparities, and increased team tensions. As unexpected opportunities presented, command of two often-underutilized components of professional expertise were essential: knowing when and how to actively listen and command of motivational interviewing skills. Both were crucial when interacting with local parents, governmental officials, clan leaders, and when providing guidance for the school children's oral home care and nutrition choices. The Ghana experience was brief, only ten days in country necessitating maximally optimizing every opportunity which presented. Part of the challenge was to accomplish as much positive impact in every presented opportunity though the daily operations varied for team members. Active listening and motivational interviewing skills helped foster the objectives of this experience.

Finally, as part of the research team, one cannot overstress the need for uncompromising **Ethics** and the value of the excellent eight: common sense, humor, patience, compassion, adaptability, flexibility, creativity, and physical fitness. If research conditions are difficult, or someone else is struggling, possession of these critical attributes may save the day, the data, and one's own sanity.

Personal Impact

"It is the human being that counts. I call gold; it does not answer. I call cloth; it does not answer. It is the human being that counts." -Ghanaian proverb

The impact of the author's experiences in Ghana was profound, very personal and as such, requires the first-person voice. For this, I ask the reader's indulgence.

Being selected to work in Ghana with Dr. Steven Duffin and his research team was a great honor. His dedication, commitment, ethics, and vision are gifts I hope every dental hygienist should experience in their professional life. My respect for his perseverance in the face of indescribable challenges is inspiring and serves as a model for anyone hoping to "do the right thing" or make our world a better place. His example has inspired me to further my own academic accomplishments and research despite any challenges, I will remain forever grateful for the opportunities he has provided. Working with Dr.

Learning from the best.

James Duffin afforded me an opportunity to work side by side with an exceptionally skilled and caring professional who enriched all with whom he came in contact with his gentleness and humor. Meeting "Nene" Kradolfer, our host, and working with Dr. Ama Ofosu-Appiah has deepened my appreciation for and understanding of the proud and generous people of Ghana. Both retain my respect and gratitude and have had an indelible impact upon my life. "Dr. Ama", as I am permitted to address her, has become a true friend and we hope to collaborate professionally in the future on behalf of dental hygiene in her country. It was she who facilitated a meeting of our team with the then Ghanaian Minister of Health, a critical step in achieving downstream implementation of the use of MMC which could lead to actualization of its benefits as an oral health strategy.

Through this experience, I have witnessed a rare generosity in Ghana's people, witnessed their courage, ingenuity, humor, warmth, and forbearance. In their children I noticed a sweetness, gentleness, and innocence which are fading in more affluent cultures. These children are brave enough to trust; eager to learn, smile and touch with generosity. The images, sounds, and majesty of the land, forest, sea, and skies will remain with me always. I am grateful to Ghana for all she and Dr. Steven Duffin have taught and given me.

The Kpetoe dance troop hired in our honor.

Conclusion

To summarize my perceptions of this amazing Ghanaian journey is difficult because so much of the richness of that experience cannot be put into words.

To describe what it felt like to dance with the Kpetoe women, to share their joy, or to be given the gift of being sung to by Togolese villages before an impromptu nutrition and chew stick oral care presentation would be futile. In summary, the perceptions of my experiences affirm my convictions that:

- Silver diamine fluoride and silver nitrate with fluoride varnish are cost-effective, humane, and safe medicaments for the treatment and arrest of dental caries.

- They are safe, effective, substantive, and easy to apply.

- Based on overwhelming evidence, downstream implementation of MMC treatment strategies within national healthcare delivery systems is critical, logical, and must be adopted globally.
- Dental hygienists can play significant roles in oral health research due to their

unique clinical, academic, and personal skill sets.

- More dental hygienists should engage in clinical research to further oral health science knowledge and develop improved access to cost-effective oral healthcare.

- Taking risks, stretching comfort zones, and doing the right thing are worth the effort.

Finally, influenced by my experiences in Ghana and with her people, having witnessed their tremendous need for improved oral care delivery, especially preventive care and oral health education, I challenge the reader with the following paraphrase:

> "Let us be the ones who say we do not accept that a child dies [or suffers] because of [an oral infection] simply because he [or she] does not have [access to oral disease prevention and care]. Let us be the ones to say we are not satisfied that your place of birth determines your right [to oral health]. Let us be outraged, let us be loud, let us be bold." -Actor Brad Pitt

References

Advancing dental public health and dental hygiene research. (n.d.). Retrieved from Rdhmag.com website: http://www.rdhmag.com/articles/print/volume-33/issue-3/columns/advancing-dental-public-health-and-dental-hygiene-research.html

Africa Guide. (2017). Ghana People and Culture. Retrieved from Africaguide.com website: https://www.africaguide.com/country/ghana/culture.htm

Alexander, J. C. (2004). Toward a Theory of Cultural Trauma. Cultural Trauma and Collective Identity, 1–30. https://doi.org/10.1525/california/9780520235946.003.0001

American Dental Association. (2016). Commission on Dental Accreditation Standards for Dental Hygiene Education Programs. Retrieved from http://www.ada.org/~/media/CODA/Files/2016_dh.pdf?la=en

American Dental Association. (2016). Professional Roles of the Dental Hygienist. Retrieved from https://www.adha.org/resources-docs/714112_DHiCW_Roles_Dental_Hygienist.pdf

Community-based participatory research : assessing the evidence (Evidence Reports/Technology Assessments, Vol. 99). (2004). Rockville, Md.: Agency For Healthcare Research And Quality.

Dental care is a human right that has evaded many African nations for decades. (2011). Retrieved from Ghanaweb.com website: http://www.ghanaweb.com/GhanaHomePage/NewsArchive/Dental-care-is-a-human-right-that-has-evaded-many-African-nations-for-decades-217181

Dickson, M., Bebermeyer, R., Hobdell, M. H., Stevenson, G., & Werner, D. (2015). Where there is no dentist (p. Introduction). Berkeley, California: Hesperian Health Guides.

Do's and dont's of silver diamine fluoride. (2016). Retrieved from Dentistryiq.com website: http://www.dentistryiq.com/articles/2016/07/the-dos-and-don-ts-of-silver-diamine-fluoride.html

Donkor P. (2006). Oral Health Manpower - What are Ghana's requirements?. Ghana medical journal, 40(4), 116–117.

Dr. Steven Duffin (2015, September 15). Dr. Parkin, Dean, University of Ghana Dental School Interview.

Duffin, S. (2012). Back to the future: the medical management of caries introduction. Journal of California Dental Association, 40(11), 852–858.

Ghana's Water Crisis - Ghana's Water In 2019 | Water.org. (n.d.). Retrieved from Water.org website: http://water.org/country/ghana/

Gocking, R. (2005). The history of Ghana. Westport, Conn.: Greenwood Press.

Health Care Quotes (106 quotes). (2011). Retrieved from Goodreads.com website: http://www.goodreads.com/quotes/tag/health-care

History of Ghana. (2011). Retrieved from villagevolunteers.org website: https://www.villagevolunteers.org/wp-content/uploads/2011/10/History-of-Ghana.pdf

Horst, J. A., Ellenikiotis, H., & Milgrom, P. L. (2016). UCSF Protocol for Caries Arrest Using Silver Diamine Fluoride: Rationale, Indications and Consent. Journal of the California Dental Association, 44(1), 16–28. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4778976/

IFDH - International Federation of Dental Hygienists. Preventive Oral Health. (2016). Retrieved from Ifdh.org website: http://www.ifdh.org/res-facts.html

Kradolfer, P. J. (2015). Ghana : everyday Life. North Salt Lake, Utah: Ghana-Art Publications And Pj&R Publications Co.

Listl, S., Galloway, J., Mossey, P. A., & Marcenes, W. (2015). Global Economic Impact of Dental Diseases. Journal of Dental Research, 94(10), 1355–1361. https://doi.org/10.1177/0022034515602879

Mayer, J. D., Caruso, D. R., & Salovey, P. (1999). Emotional intelligence meets traditional standards for an intelligence. Intelligence, 27(4), 267–298. https://doi.org/10.1016/s0160-2896(99)00016-1

Mei, M. L., Lo, E. C., & Chu, C. H. (2016). Clinical Use of Silver Diamine Fluoride in Dental Treatment. Compendium of Continuing Education in Dentistry, 37(2), 93–98.

Regional Office for Africa. (2009). World Health Organization. Retrieved from http://www.who.int/countries/gha/en/

Rubio, D. M., Schoenbaum, E. E., Lee, L. S., Schteingart, D. E., Marantz, P. R., Anderson, K. E., … Esposito, K. (2010). Defining Translational Research: Implications for Training. Academic Medicine, 85(3), 470–475. https://doi.org/10.1097/acm.0b013e3181ccd618

Search of: silver diamine fluoride - List Results - ClinicalTrials.gov. (2019). From Clinicaltrials.gov website: https://clinicaltrials.gov/ct2/results?term=silver+diamine+fluoride&Search=Search

The Guardian. (2011). Ethics left behind as drug trials surge in developing countries. Retrieved from https://www.theguardian.com/global-development/2011/jul/04/ethics-left-behing-drug-trials-developing

The State of Healthcare Delivery in Ghana. (n.d.). In ghanaphysicians.org. Retrieved from http://ghanaphysicians.org/wp-content/uploads/2015/05/KenSagoe.pdf
Why Cultural Competence? (2015). Retrieved from National Education Association website: http://www.nea.org/home/39783.htm

World Bank. (2015). Gross national income per capita 2015, Atlas method and PPP. In worldbank.org. Retrieved from http://databank.worldbank.org/data/download/GNIPC.pdf

MMC Project in Bolivia

(Dr. Steve. Duffin, DDS and Marcus Duffin, MS, MBA)

In August of 2017 we had the opportunity to travel to Bolivia to execute a large scale (3,500 children) demonstration project in collaboration with Choice Humanitarian www.choicehumanitarian.org in the area around Copacabana and on the shores of Lake Titicaca. This large community program was made possible through the generous support of Mr. Fraser Bullock who lived in Bolivia during the 1970's and holds a deep love for the children of this beautiful country. Permission for this program was obtained from the La Paz District ministry of health office, parents and all local school administrators.

At the time of publication, we have not finished collection of outcomes data for this project but will provide some images and commentary from this project.

Collaboration with choice humanitarian.

Children at island of the sun.

Lake Titicaca.

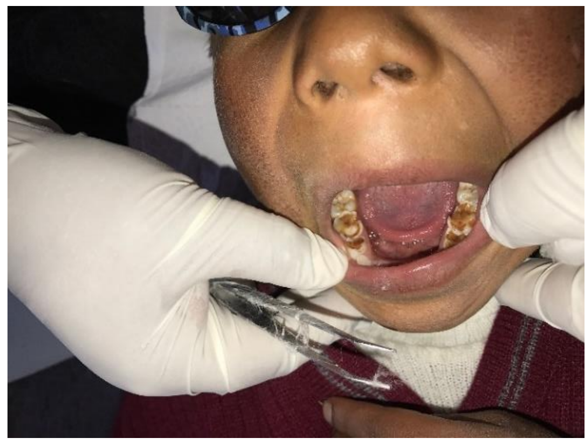
Dr. Duffin and Tiffani Kealiher from Shoreview Dental, LLC.

It was rather cold at 14,000 feet!

School clinic in high gear! Dr. Maxi Mendoza Choice Humanitarian Bolivia.

Clinic was set up in a school science laboratory.

Typical severe decay.



Destroyed molars.

Dr. Mendoza treating children in the classroom in Bolivia.

Delivering SDF and fluoride varnish in the classroom in Bolivia.

The following is a link to an interview with the Bolivian dentists who participated in this project.

- https://youtu.be/CGmGS2k_Kls

A second project with Smiles Forever Foundation was developed in the Chapare region of Bolivia .

Smiles Forever Foundation – Bolivia

(Sandy Kemper, RDH)

My name is Sandy Kemper, and after 20+ years as a clinical dental hygienist in Seattle I was ready to seek adventure in my dental hygiene career through humanitarian work abroad. In 1999 I traveled to Cochabamba, Bolivia with David Crane DDS, owner of Dental Seminars and symposium. Little did I know that that this trip would develop into an experience that would change the course of my entire life.

Cochabamba is the third largest city in Bolivia following behind La Paz and Santa Cruz. It is located in a valley of fertile lands in the central zone of the country, in the sub-Andean region sitting at the foot of the Tunari Mountain Range. Cochabamba has an altitude of 8,400 feet above sea level. The sunny dry highland weather is often referred to by all as "The City of the Eternal Spring." Unfortunately, this also provides a haven for the many homeless living on the streets in the city of Cochabamba. It has been estimated that there are approximately 4,000 homeless people from within a total population of 1,762,761 inhabitants.

I was delegated to work in a homeless shelter for women and children, Madre de Dios, where many had found their way. This shelter was actually a "catch all" center for those the authorities had no place for. Most of the young women living in Madre de Dios had been raised in the government shelter system. The women were taught basic skills such as cooking and cleaning, young men were taught vocational skills. However, few finished high school and little vocational training was available to them. Vocational programs. College was unheard of for these young women. After living on the streets many would return to live in the shelter system, poor, uneducated, and with children. The shelter had a small one room dental clinic that housed one worn dental chair, a broken suction unit and a small oven of sorts for improper sterilization. The windows were broken and the heavy dust and dirt that pollutes Cochabamba permeated the room. Cockroaches were abundant crawling from the drains and hiding amongst the dental supplies. The children had carious lesions on almost every tooth, abscesses were numerous, and many had early onset periodontal disease. With minimal resources we filled as many teeth as we could, however many required extractions. I mostly gave out toothbrushes and wished them luck. Prevention was unheard of at that time. It was truly heartbreaking to see the neglected state of the oral health of the children. I was determined to do something about this situation and returned to the United States to make a change.

My vision was to treat and prevent oral diseases and to make a difference in the lives of these young women and children residing in the

shelter. I spoke to anyone that would listen to me: parents, friends, fellow hygienists, dental hygiene students, dentists, physicians and other health care providers. To make a long story short, we all rallied together with money, abundant energy, and dental knowledge. We created the Smiles Forever non-profit organization in 2000. It was determined that the mission of Smiles Forever was to improve the quality of life for impoverished children through free preventative and restorative dentistry. Additionally the Smiles Forever program supported a unique educational model for disadvantaged women and mothers to become professional dental hygienists within the Smiles Forever foundation. However, this proved to be a daunting task in a developing country where the profession of dental hygiene had never existed.

A very basic two-year vocational training program was created with the University of Kentucky. Lesson plans included basic skills such as personal hygiene and communication in general. The program was translated by our Bolivian director Alejandro Beckrich and onsite Bolivian staff dentist Paola Escobar. A psychologist was hired to help with all the social and psychological issues that come hand in hand with a low social economic background. After three years (some students were still finishing high school at the same time) the first class of six dental hygienists graduated. Graduating students gained an incredible amount of knowledge about dental assisting, attending the front desk, as well as working as hygienists in the Madre de Dios dental clinic that served approximately 1,000 people, predominantly disadvantaged children. All graduates were able to gain employment in local dental clinics after graduation.

Many changes have occurred over the last 18 years. Smiles Forever is the only established functioning dental hygiene program in Bolivia. Smiles Forever received in 2011 from the world federation of Dental Hygienists that “The dental hygiene society of Cochabamba” has been

accepted as a member of the World Federation of Dental Hygienists and the only Latin American representative of Dental Hygienists.

The curriculum has continuously been revised with the help of many volunteer dental hygiene professionals from the Pacific Northwest. Dr. Sharon Golightly, past director of Pierce College dental hygiene program and Rosie Bellert current director of Shoreline College, Dental hygiene program, have been deeply involved in this process. Debra McGlynn RDH BS donated countless hours revising instrumentation with Smiles Forever clinical staff. Madre de Dios closed its doors and Smiles Forever relocated opening a new dental clinic and school. To date 37 students have graduated from the Smiles Forever dental hygiene Program. 5 graduates have gone on to study dentistry at the local University. One such graduate, Dr. Nayda Apata, is now head of the Community service clinic at Smiles Forever. This clinic has provided complete preventative and restorative dental care to over 37,000 impoverished children over the last 18 years. These patients come from the 35 different NGO'S/shelters in Cochabamba. These NGO's /shelters include children that lived with their parents in jail, children affected by HIV, cancer, and severe burns. Over the years we have developed various community service projects in rural communities outside the city involving preventative care followed by sealants, emergency dental care, extractions and referrals to local dentists.

The most successful long-term project has been developed over the last 3 years in the jungle area, 4 hours from Cochabamba in Villa Tunari, one of the towns of the province Chapare. With a population of 3,213 inhabitants, with a poverty level of 78.6%. In impoverished communities such as these the school becomes the hub of the community. Therefore, we chose to start our Silver Diamine Fluoride project at the Maria Del Rosario school of 696 students (April 2018). Ranging in age from 4 to 19.

The climate of Villa Tunari is hot and humid most of the year, enticing children to keep hydrated. Unfortunately, the children are bombarded with sugary treats as they enter the school by vendors standing at the entrance, selling ice cream, penny candy, coca cola, and sweetened cinnamon sugar water. We often would see children sucking on suckers during school which was allowed by the teachers.

In September of 2015 with the help of Katie Flemming RDH and Shoreline Dental Hygiene School we introduced a basic demonstration project with tooth brushing skills and nutritional education followed by an application of SDF. There were 490 children enrolled at the school, however only 176 received silver diamine fluoride (SDF) treatment. Although we went to great efforts to educate the teachers, parents and directors, some felt we were experimenting with their children. At times we only two portable dental units with air syringes and most treatment was provided on tabletops. From the information we had about SDF at that time, SDF was applied to class I and Class II caries only. This was the first time for many of us using SDF. We felt we had a lot of contamination from saliva and staining of SDF on the mouth of patients and everywhere else. Basic information was documented such as sex, age, and teeth applied. Because this was only a demonstration project we did not have a standardized charting method at this point. Unfortunately, we did not have funding to return in the following year.

Promoted by Elise Tanner RDH director of Tooth Fairies we contacted Dr. Steven Duffin who has worked continuously with SDF. This allowed us to develop the very latest protocol and standardize the charting method, which has allowed us to collect accurate statistics from this information.

With their help and the growing concern to keep this project running we were able to receive funding for a yearlong research project through the West Foundation.

We returned in September 2016, one year later, with only Smiles Forever staff. With experience of the primary trip and Dr. Steven Duffin we developed the basics of the SDF protocol and the standardized charting method. This time we were received with a higher level of acceptance by teachers and parents.

At our last visit a student and a professor from UPAL University participated in the study. They were extremely impressed and wanted to return.

After completing the three-year study, we reevaluated the students every 6 months, and found a remarkable reduction of caries, increased number of arrested caries, increased health of gingival tissue in general and overall health. There was not a decrease in weight of the children and there was an increase in height which reflected the improvement of the children's nutrition. However, we had some carious lesions that were not arrested that needed extractions or root canal therapy. Any student that had a fistula was given the opportunity to be transported to our clinic in Cochabamba to be treated for no charge. Although this was explained repeatedly to parents it was difficult to get them to comply. Because the results of this program are so favorable, we are motivated to apply for funding for the next three years to continue the SDF project and take it to the next level using Glass Ionomer Cement and other permanent restorative materials.

SDF PLUS FLUORIDE VARNISH PROTOCOL

PREP AND EXAM:
All teeth should be cleaned of food, debris and plaque.
Revaluate the last exam
SDF is placed on only Class I, Class II, Class III caries and some virgin teeth that have been noted on the chart.

NOT: Pulpal Involvement and Irreversible pulpitis

SET UP: Mirror, Gauze, Compressed Air, SDF Flo, Flo Varnish, 2 well dappen dish, 2 microbrushes, glasses for protection paper towel

DISPENSE MEDICINE INTO DAPPEN DISH:

1. Dispense one drop of SDF into one side of dish
2. Dispense small amount of Flouride Varnish in the other end ..to the top

APPLY MEDICINE

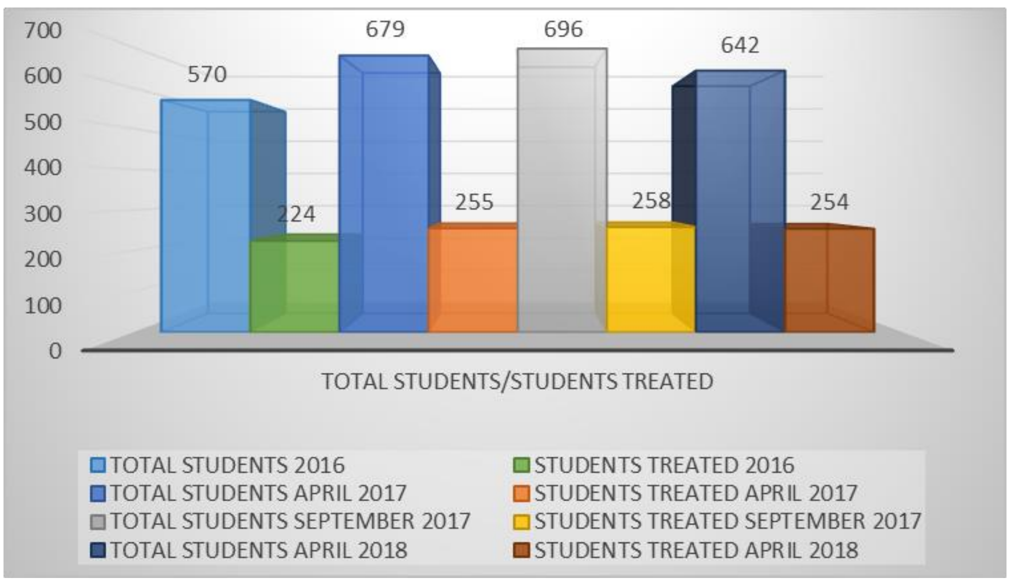
ISOLATE EACH AREA YOU ARE WORKING IN WITH COTTON ROLLS

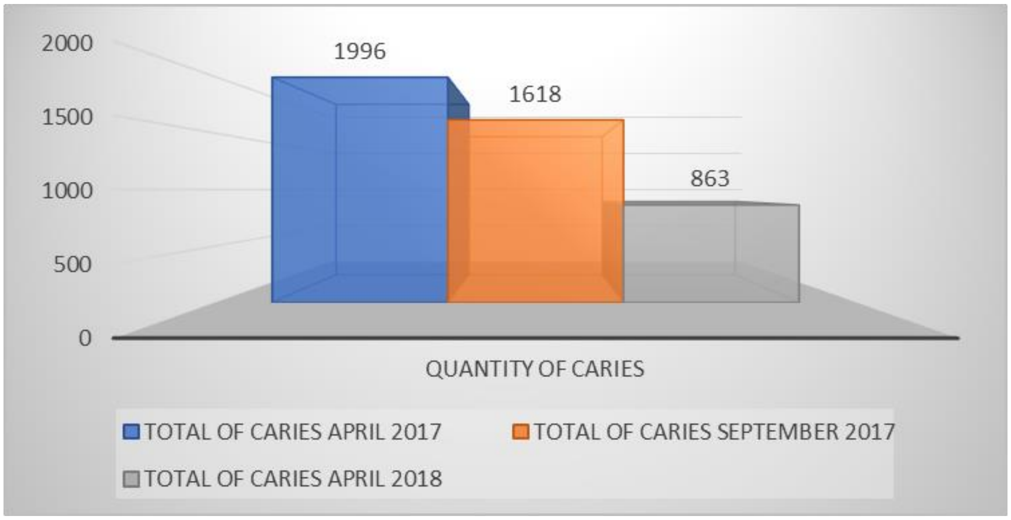
1. Each lesion should be wiped with gauze to catch most of the salvia, then thoroughly dried with compressed air.
2. Dip micro brush into SDF
3. Apply SDF to dried tooth
4. Immediately cover with Fluoride Varnish using the OTHER microbrush

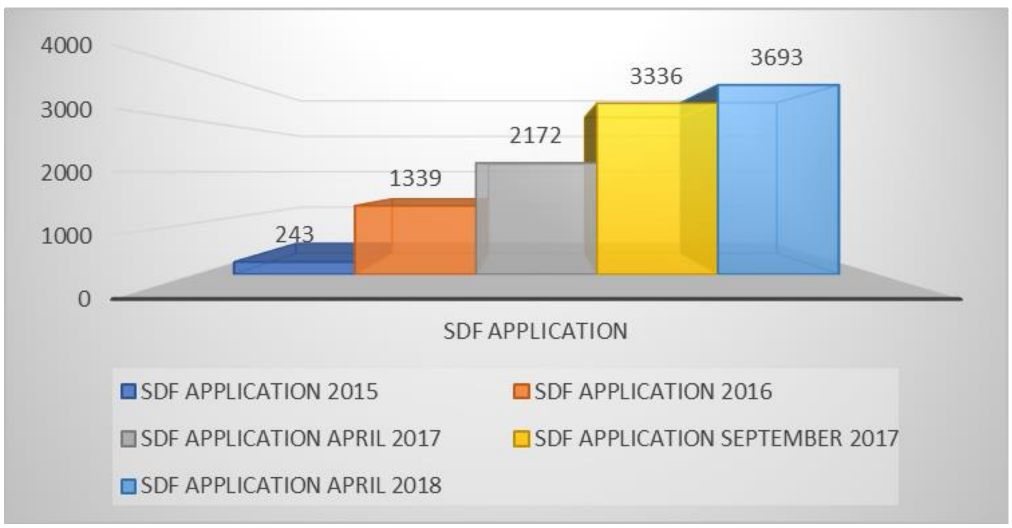
NOTE; SALIVA CONTAMINATION WILL DRAMATICALLY REDUCE THE EFFECTIVENESS OF THE TREATMENT. IF SALIVA CONTAMINATES THE TREATMENT AREA, START OVER. IF BRUSHES ARE CONTAMINED WITH SALIVA, CHANGE BRUSHES AND START OVER.

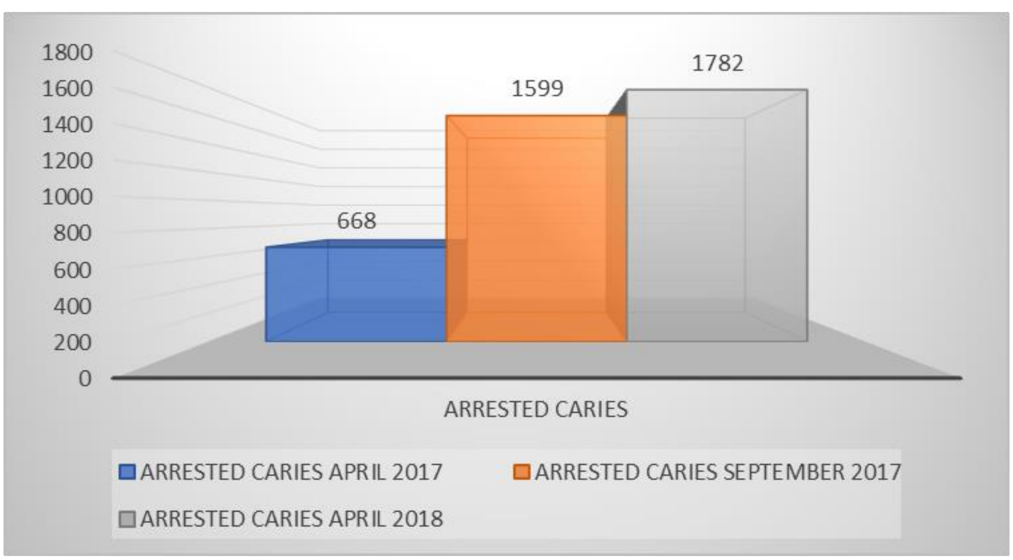
In 2018 the World of Children foundation awarded their annual Health Award to Sandy Kemper and the Smiles Forever program in Cochabamba Bolivia. This award is considered one of the most prestigious accomplishments of any organization working in the humanitarian field.

Smiles Forever Program Data




2000
1500
1000
500
0
1996
1618
863
QUANTITY OF CARIES
TOTAL OF CARIES APRIL 2017
TOTAL OF CARIES SEPTEMBER 2017
TOTAL OF CARIES APRIL 2018


4000
3000
2000
1000
0
243
1339
2172
3336
3693
SDF APPLICATION
SDF APPLICATION 2015
SDF APPLICATION 2016
SDF APPLICATION APRIL 2017
SDF APPLICATION SEPTEMBER 2017
SDF APPLICATION APRIL 2018


1800
1600
1400
1200
1000
800
600
400
200
0
668
1599
1782
ARRESTED CARIES
ARRESTED CARIES APRIL 2017
ARRESTED CARIES SEPTEMBER 2017
ARRESTED CARIES APRIL 2018

The Tooth Fairy in Bolivia, a Dental Hygienist's Reflection

(Kellie Whitcomb, RDH, BSDH, MSDH(c))
Co-Director of the Tooth Fairies School-Based Oral Health Program

Almost 20 years ago Elise Tanner and Nancy Alleman created and developed The Tooth Fairies, a school-based oral health program in Washington state. Elise then became the sole director and provider for what had become a sustainable community outreach program all across Puget Sound serving elementary schools and more than thirty Early Childhood Education and Assistance Programs (ECEAP). The Tooth Fairies provide dental assessments, fluoride varnish applications, and most importantly, oral health education delivered in the ultimate kid-friendly way: dressed as a Tooth Fairy using an oversized tooth and fuzzy bacteria puppets. Fast forward fifteen years to a fortuitous meeting between Elise and myself at an Alliance of Dental Hygiene Practitioners forum, and a new chapter for the Tooth Fairies and for me began.

A few years ago, I decided to pursue what I am most passionate about, connecting access to care for those who are most vulnerable. My initial focus was on the Silver Tsunami, senior citizens that comprise the largest growing population group with many accesses to oral health care issues. Sitting next to Elise at the forum, she turned to me and asked a simple question: "But what about the kids?". Having two small children of my own, this question hit me. She invited me to join her Tooth Fairies for a day, just to see if it was something that I would want to be a part of. A day at Daffodil Valley Elementary had me convinced. I had to be a part of this program that was doing so much good. The children emphatically welcomed Tooth Fairy Elise and her team, but what struck me most was how they had retained her oral health message about the etiology, transmission, and prevention of decay she had delivered six months prior in their classrooms. Her unique approach dressed as a childhood icon related to teeth really captured the attention and interest of the children. I have been working with Elise and her team of registered dental hygienists for two years now and proudly wear my Tooth Fairy dress and tiara as I advocate for children's oral health.

Elise has imparted her knowledge related to independent practice as a hygienist within an educational setting to me and I am so grateful to her as a mentor and friend. Her passion for eliminating the experience of early childhood caries is contagious. The lofty vision of eradicating decay should be at the top of every registered dental hygienist's list, for we are prevention specialists, after all.

During our time together, Elise told me about a friend and fellow hygienist, Sandy Kemper and her non-profit foundation, Smiles Forever. 'Smiles', as it is casually referred to, trains indigenous women to be dental hygienists and provides dental care for those living in Cochabamba, Bolivia. In addition, the Smiles dental hygiene training program has been providing oral health education, dental assessments, dental cleanings, and silver diamine fluoride treatments for an elementary school in Villa Tunari as a community outreach program. Elise joined Sandy and Smiles for one of their school visits and was indelibly convinced that Smiles Forever's use of silver diamine fluoride was making a huge impact on the children's experience of decay. Imagine my surprise and excitement when Elise asked me if I would return to Bolivia in her place and represent the Tooth Fairies for Smile's next school visit.

I learned many things from my trip to Cochabamba and to Villa Tunari in the Chapare region. After delivering the oral health presentation as the Tooth Fairy, with the help of a translator to several classrooms, I discovered that the cultural mythology of the Tooth Fairy does not exist in Bolivia. I felt embarrassed for not knowing this prior to donning my winged dress and tiara. I have learned through advancing my education that cultural sensitivity is imperative when approaching any type of outreach. The children in Bolivia believe in the Tooth Rat, a different myth related to the loss of a baby tooth. The Tooth Fairies intended to leave Smiles Forever with all the tools of our school-based program with the hope that our success in educating children about oral health in the states could be duplicated in Bolivia. Had the Tooth Fairies already missed the mark?

To add to this cultural oversight, another concern arose. I noticed a hesitancy from Smile's dental hygiene students to be the Tooth Fairy in front of the elementary students. After inquiring about it, I was told that to wear a professional uniform was a symbol of esteem and sought after by people in Bolivia. Wearing a costume while trying to engage in their work would be making a mockery of themselves. Now I had two hurdles to overcome!

For several class presentations, I modeled the oral health education portion of our program in front of eager and smiling students who clamored around me to fluff my dress, touch my wings, and hug me with outstretched arms. The students' response to the Tooth Fairy put to rest my worry of our cultural differences. I learned that children have similarities no matter where they come from or what language they speak. Eye contact and a genuine smile can make a strong connection in the absence of a common cultural belief or even a common language. Glitter and sequins help, too. The hesitancy of Smile's dental hygiene student, Adele, melted away as she saw how adored the Tooth Fairy was. That afternoon, this brave future prevention specialist put my dress on and replicated what I had demonstrated earlier in the classrooms.

I was so proud to see her put aside her fear, knowing what a difference she will make by educating children in such a child-friendly way.

I also learned that the profession of dental hygiene does not exist in Latin America. Smiles Forever has been actively pursuing accreditation for their curriculum and licensure for their

Adele Bolivian dental hygienist.

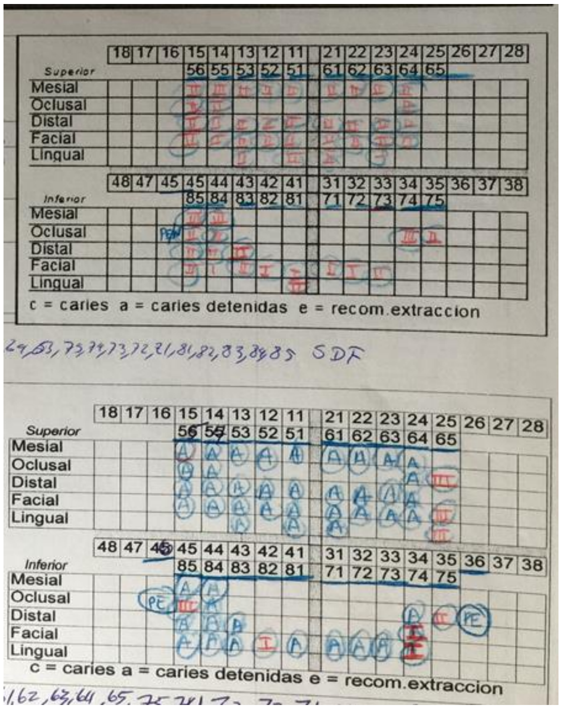
Sandy kemper, RDH.

graduates. However their efforts have been met with opposition because it had never been done before. Leading up to the time of my visit, Smiles Forever had a series of meetings with Universidad de Privada Abierta Latinoamericana (UPAL), a private university in Cochabamba, to discuss a possible partnership or adoption of the Smiles Forever dental hygiene program. An agreement has been made, and the future for a dental hygiene profession in Bolivia is bright.
When I first heard about Sandy, I recall thinking what a change agent and difference maker a person with a passion could be. She and her team have not only provided dental care for tens of thousands of Bolivians, but also brought the profession of dental hygiene to Latin America for the first time.

I am awed and humbled to have been in Cochabamba the day the agreement between UPAL and Smiles Forever was signed. For someone who's childhood dream was to be a dental hygienist, I cannot express how meaningful it was for me to see my profession advance in such a major way right before my eyes. Because of Sandy Kemper and Smiles Forever, there will be future five-year old's dreaming of making a difference for people as a dental hygienist, just like I did.

Finally, my time with Smiles in the Chapare region further convinced me that silver diamine fluoride works. While working at the school, Dr. Steven Duffin shared with us the history of SDF, research related to its use, and his clinical experience with it. Dr. Duffin's mentoring was invaluable. I use SDF in my independent senior focused practice in Washington, so I have seen for myself how this antibiotic liquid turns soft, active decay into hard, arrested lesions. However, my senior patients are at the end of their lives, so I rarely get to monitor these areas for more than a year. This is where Smiles Forever helped me to see the longer-term effects of the application of SDF on a carious lesion.

Smiles has been providing assessments and SDF with fluoride varnish every six months for the last 18 months at the time I was there. Chart after chart showed rampant, active decay written in red pencil at initial visits. These areas were treated with SDF and fluoride varnish. Six and twelve months later, these areas were charted in blue pencil as hard, arrested lesions.



Chapare dental chart.

If this wasn't amazing enough to witness documented over and over again, there were very few new active areas of decay noted in the hundreds of children we saw. How is it that there was almost no new decay in a population where sugary snacks and soda pop are less expensive than bottled water and there has been very little dietary or oral hygiene behavior modification efforts? If I hadn't seen the rampant amount of caries in a state of arrest for myself, I would have thought the data to be exaggerated. I will never forget how such a small drop of an inexpensive liquid made such a massive positive impact. And without local anesthetic, a drill, or sedation, I might add.

I have mentioned that registered dental hygienists are prevention specialists. Our training has also made us critical thinking experts. I have seen first-hand the epidemic of

Teaching nutrition and oral hygiene.

early childhood caries, in the jungle of Bolivia and in my own and neighboring counties. For the children who suffer from its pain, days missed in school, an d for some, death, I am left with the uncomfortable question to ask: are we doing our job well enough? There is no better time than the present to return to our roots of caries prevention, especially while having SDF at our fingertips. The Smiles Forever community outreach program is an excellent model of how caries can be arrested in oral health related programs, right here where we live and all around the world.

The Tooth Fairies aim to do just that. Even prior to my own experience with Smiles Forever, Elise had inquired about implementing SDF applications within our ECEAP sites. Although we have been met with firm opposition, we will continue to advocate for its use in our school-based program. In the meantime, I created an informational brochure about SDF for the families of the children we serve. By bringing awareness to this treatment option, our hope is that parents will begin to ask their dentists for it. We have also compiled a list of dental offices in our region that offer SDF as a treatment option and we provide this resource to all of the student's families we see.

This last Fall, dressed as a Tooth Fairy in a local ECEAP site, I saw my first official baby tooth that had been treated with silver diamine fluoride. There have been a handful of other children that have been treated with SDF to follow, and I anticipate seeing more with each classroom visit.

I view these small beginnings as a tell-tale sign that dentistry is changing, and I am once again humbled to not only witness it, but also to be a part of it.

Smiles Forever Dental Clinic

(Dr. Nayda Apata Rojas)

In dentistry, which is usually restorative, the objective to be achieved in the treatments we perform every day is very precise. One of the most common processes performed in the daily clinic, are the restorations with composite resins and therefore we must devote a time to their knowledge in order to obtain reproducible results and easy reach for all. Many times when we are at a high risk where more than 80% of their teeth have deep cavities and even worse that the patient is under the age of 8, so, what can be done. This is where the following question arises: What is the most appropriate treatment in these cases? Consider that young children and often are uncooperative and restless.

During the patient care at the Smiles Forever dental clinic I had the opportunity to see different types of patients in which more than 70% of them had very deep and extensive second-degree caries. In which I chose to perform the treatments of pulp protections, placement of Ionomers, resins and in the worst cases endodontics and finally the extraction of the pieces, it really is a great job considering that many of the children with whom they treated were under eight years and many of them little collaborators was sometimes very difficult to serve them and that frustrated me greatly. This is where we could appreciate the properties of diamine silver fluoride (SDF) and start using it. The work was greatly facilitated not only with the application, but also because it is a non-traumatic treatment for the patient where the application is fast and without pain, it is one of the qualities that favor when using it. I think that in children it is a great option since the SDF for its properties of presenting Silver is a great antibacterial agent that greatly reduces the number of bacteria that occur in the carious lesions, and the most impressive thing that stops the advance of the Caries is amazing. I would like to share one of the cases I had with the attention of a child he had three years old, he had 80% of carious lesions all over his mouth and the worst thing was that as soon as he sat in the dental chair he began to cry and screaming, take care of him was a big problem because he also complained of pain, the first thing that was done was that he trusted us, something complicated because he also had to deal with the pain he had at that moment. Well we could deal with that inconvenience and once I entered into trust with us we could apply the SDF on all the pieces that had cavities, the child was disturbed at first but later on seeing that this procedure did not hurt and that it was very fast not I dislike him at all. That way in a few visits we were able to control that situation, what draws attention was that he had quite deep caries in which we thought that many of them could end up in endodontic treatments but until today that the child already has an age 5 years old he is calm without discomfort. Of course he always goes to a control every three months to perform a control in addition to each visit he is an increasingly cooperative patient and has the confidence to come and visit us to be seen.

Photograph of the anterior teeth where you can observe that the SDF stopped the advance of the carious lesions.

Panoramic radiograph four years after SDF application.

My Journey to Bolivia and the Smiles Forever Caries Control Program

(Dr. Sharon Golightly, EdD, MS)

Little did I know that during my high school years my choice of a foreign language class would end up influencing the course of my life. I choose the Spanish Language to study, I logically assumed that it would be most useful to me anticipating living in California at the time.

A few years later, upon graduating from college with a degree in Dental Hygiene, I choose to serve my country by volunteering for the Peace Corps instead of going into a dental hygiene private practice. It was to me surprising that I was accepted for Peace Corps training and more than that to be trained to go to the country of Brazil where they spoke Portuguese. The training included learning skills in Community Health and Development, Intensive Language Training and Physical Training. Surprise me again, I passed all parts of the Training and was selected to go to Brazil in the winter of 1964.

Upon arriving in Brazil, I was greeted at the airport by the Peace Corps Country Director and informed that I would not be going into the interior of Brazil, but would stay in Rio de Janeiro and work on a dental health project. That project was to train the assistants in the Dental Clinics in the State of Guanabara with the State Department of Health on how to work more productively with the clinic dentists and to improve methods of sterilization and disinfection. It meant traveling to all the clinics in the state by bus, train, or by walking.

Meanwhile, I needed to find a place to live and took over a house a returning Peace Corp Volunteer was leaving to return to the States in a favela (slum) called Morro do Borel, which was in the Tijuca section of Rio de Janeiro which was in the northwest section of Rio. I acquired a roommate from Wisconsin who was trained as a Visiting Nurse. Since I had considerable health science education with my degree, my knowledge came in helpful to assist my roommate. and I was able to do extensive health work in the Favela by opening and staffing a health clinic there, providing all kinds of health care, preventive procedures and health maintenance. We were able to enlist volunteer help of a retired physician and another part-time physician to staff the clinic. During that time, I was able to institute a topical fluoride application program in the Favela to prevent dental decay.

I also instituted a mobile dental care program staffed with state dentists and assistants with the public railroad system and move a railroad dental care around the state to provide care to more remote areas. The State Government provided dental care for Pregnant Mothers and Children under six at the time.

In 1966 I returned to the States and entered into private dental hygiene practice for various dentists for the new ten years. During that time, I obtained a Post-Secondary Teaching and Supervisory Credentials from UCLA with teaching in mind as a definite option in my future. That opportunity came when I was offered the Directorship of the Pasadena City College, but could not accept the offer because my husband wanted to return to college and finish his degree. So, we moved to Northern California where I found a position to teach Dental Hygiene at Sacramento City College. I taught half-time and worked for the Sacramento County Public Health Department the other half-time. I also worked in private practice dental hygiene for a half-day a week.

An opportunity to assume the Directorship of a Dental Hygiene Program in Washington State was offered to me in 1975 and I took the job that was offered at Pierce College in Lakewood, Washington and served at its Program for the next 31 years. During that time, I was able to include in the curriculum a robust Public Health Program coupled with an extensive Extramural Program with community outreach. Student's work in Federal Prison facilities, Indian Tribal Clinics, Schools for Special Needs Children, Mental Institutions, Veteran's Facilities all based on taking preventive services to the underserved.

It was during this time that I had Sandy Kemper with Smiles Forever come and share with the students about her Foundation and the work she was doing in Bolivia. I became personally involved because I believed in the cause and believe in giving something back to others less fortunate. Sandy and I discuss the possibility of my coming to Bolivia to help her establish a Dental Hygiene Program, which I did in 2007 when I had just retired from Pierce College. We worked on a curriculum which we successfully submitted to the government of Bolivia and was accepted as a Certified Program of Dental Hygiene for the young women that were living at a shelter called Madre de Dios. Since that time, over 37 Dental Hygienists have graduated from the program and a handful have gone on to become dentists. In fact, two are now working at the Smiles Forever Clinic. We designed a strong community public health part of the curriculum and included a first program shortly after the inception of the program a Fluoride Varnish Program in a Village of Coriani Pampa. We saw rampant decay in the children's mouths and were very frustrated regarding the easy access for the children to decay causing foods (there was a candy shop at the end of the playground). It seemed to us that all the children were going around with penny suckers in their mouths', it all seemed so defeating. We saw many children with abscesses and oral infections in pain. There was a dental clinic in the village, but no dentist.

In the intervening years, when I could I would visit with Sandy and catch up at the annual Smiles Forever Fund Raiser for this continuing project. My personal circumstances allowed me to return to my first love, that of being in service to others. I had the opportunity to become re-involved by returning to Bolivia to help with a new outreach program in the village of Tunari at a K-12 school and more importantly to work with a local private university dental school to include a curriculum for bachelor's degree program in Dental Hygiene.

I became involved in the Silver Diamine Program after the first year of its initiation. I was amazed at what I saw in the children's mouths. Decay was halted, very little new decay was encountered, children were not in pain and the children appeared more robust as far as their overall health. In essence I became a believer in SDF!

This project has been a cooperative project with Smiles Forever providing their equipment and their Dental Hygienists, Assistants and Dentists as well as the consumables for patient treatment. This project has taken an army of volunteers from Shoreline Community College, many Dentists, Dental Hygienists, and Assistants and other skilled volunteers from the states. Included with all of these volunteers were a contingent of dental hygienists who not only treated the children, but went into their classrooms with their Tooth Fairy costumes to educate the children about oral hygiene and making good food choices.

The Smiles Forever has visited this school in Villa Tunari every six month for the last three years and applied Silver Diamine Fluoride to the same children and adding new children who transferred into the school or enrolled in the school. The program is well accepted by the parents and teachers of the school and have commented on the overall improved health of the children of the school.

With our visits to the school we have involved staff from the Smiles Clinic from Cochabamba that includes the Bolivian staff of dentists, dental hygienists and assistants. The staffing included various volunteers from the United States, including dental hygienists, students and faculty from Shoreline Community College. One of the volunteers owns a dental hygiene business called "Tooth Fairies" that provides preventive oral hygiene services to children in schools including

dental sealants. The dental hygienist employees employed in the program dress up in Tooth Fairy costumes and they did the same in the school in Tunari and were able to get the Bolivian dental hygienists and assistants to go into the various classrooms and teach oral hygiene to the children.

For the last year, the program has been working with a private university (UPAL-Universidad Privada Abierta Latinoamericana) Dental School in Cochabamba who has been working cooperatively to send dental students to work with the rest of the Smiles volunteers with this community health project in Tunari. It is hoped that UPAL will take over the program as a part of their community outreach and interprofessional educational competencies.

This program has been so successful that the other school in town has approached Smiles to include their school's children in the project because they have seen and heard about the benefits of the reduction of decay in children's teeth. Preliminary comparative data indicates a possible reduction of new decay by 90% and an enormous reduction of pain being suffered by the children with a program of like this.

Soon, we will have the scientific data to document our finding and outcomes and it is planned that it will be shared as well as presenting the program's data to the Ministry of Health in Bolivia to make such a program nationwide.

Exchanging Sugar for Water

(Elise Tanner, RDH, BS)

I am Elise Tanner and I am a Washington state Registered Dental Hygienist and President of The Tooth Fairies. I and a colleague, Nancy Alleman RDH, BS started this School Based Oral Health Program called "The Tooth Fairies" in 2001. Nancy retired in 2011 but is still on board as a consultant. Since then, we are now a group of 10-13 dental hygienists, 2 dental coordinators, and a statistician. We are really spreading our wings!

Scientifically, it has been shown that dental decay is a contagious disease caused by biofilm on tooth structure, this biofilm is composed of various microorganisms plus a source of energy (carbohydrates/sugars) when added to the oral cavity. My interest has been to put the etiology of dental decay into language that even the smallest child can understand with terminology and visual props to explain dental decay. If they can understand what happens on their teeth when they eat/drink sugar they just might think about what they drink, eat and how they brush their teeth. Either choose water over sugar water or rinse off the sugar from your teeth and make sure to brush off the bugs and the poop (acid) they make!

My approach with The Tooth Fairies is to work with super intendants, principles, school nurses and teachers in preschools and elementary schools. We educate them about the importance of educating and

inspiring children and their parents to want to take personal responsibility of their teeth. I have found that many of these people do not understand that caries is a communicable, bacterial infection and the role sugar plays on the bacteria. I know this because of how they react to our presentation to the children. Many also comment “I didn’t know that!” after the presentation. Unfortunately, many of them have a soda pop sitting on their desk.

Preventative dental services help a great deal to prevent tooth decay, however, if the environment in the mouth is constantly being bombarded with sugar, nothing will prevent rampant tooth decay in small children. The only way to combat it, is to identify and remove the sugar habit. The habit can be tricky to identify, but with rampant decay, there always is a way.

I have known about Sandy Kemper’s program Smiles Forever since about 2001. Around 2015 Sandy started taking her students, dentist and other hygienist she recruited from the US to an elementary school in Villa Tunari, Bolivia to provide dental hygiene services, including Silver Diamine Fluoride.

In December 2016, Sandy invited me to join her in Villa Tunari as she really could use my help in her elementary school program. In April 2017, I volunteered to come to Villa Tunari. I showed the Bolivian hygienist in the classroom how I teach the etiology of caries and the importance of drinking healthy water to children. I did not take my tooth fairy dress down with my first visit as I wanted to introduce my ideas slowly and felt the dress might be overwhelming. I knew they had a tooth mouse but didn’t know how much or if they knew about the Tooth Fairy. When teaching my presentation (my husband insists it’s more like a puppet show), I can be quite animated, this helps keep their attention. I show how the bugs “poop” on their teeth when fed sugar, softens the tooth and makes a cavity. I push the bugs with poop on them into the tooth’s cavity on the tooth and they almost disappear. I tell them this poop smells bad, it’s bad breath! When I talk, I walk around the desks so all the kids can see the bugs going into the tooth making a cavity. While doing so, I noticed that many kids (and also some teachers) were sipping on a straw with a bag of brown water. Later to find out its sugar, water and cinnamon they buy at the "in school snack lady" for 2 cents. Most of the children buy these "bags" either before school, at recess and or after school to eat with their lunch before going home. These bags were all over on the school grounds, just thrown down. I felt this could be the sugar habit I was looking for.

I started asking questions like: 1. What is in these bags that's so good? 2. Why are they allowed to bring them into the classroom? 3. How are they made? 4. Why is this "snack lady" able to sell this product so cheap? The answers: 1. Sugar, 2. Because the teachers drink them in class and 3. The snack lady makes them herself. 4. Sugar, cinnamon and boiled tap water. My answer was to get rid of them from the school. Of course, this didn't go over easily with anyone. This is a

Young mother with her 1 1/2 year old, waiting for the snack lady to open the sugar store.

multifactorial problem, I don't want to put the snack lady out of business, it's her livelihood. I don't want the school kids to hate us because we took away their sugar water! I needed to come with a diabolical plan to make them change their minds about these bags of sugar water.

While staying in Villa Tunari, I ventured out with the Bolivian hygienist to the little down town area. We visited their "market" as I love these in all countries I have been. (I travel quite a bit). I noticed even the smallest of children with their moms at work, were sucking on the "bags" of sugar water. It seemed to me, perhaps they weaned their children from the breast to the bag of sugar water. She is working and needs to pacify her child in order to conduct business. So, this sugar habit starts very young, comes from the parent, is ingrained in their society and is a part of their everyday ritual. It's also rotting their children's teeth so they cannot eat their healthy indigenous

food. I do not think any amount of fluoride varnish, sealants, or brushing, would ever make a dent in reducing or stopping further destruction of these children's teeth now or in their future. I feel their only hope is Silver Diamine Fluoride treatments and caries prevention education. They have to want it. I believe no parent ever wants to do harm to their child, they will change if given the right education, chance and a good alternative. Perhaps these parents do not know what normal healthy teeth look like any longer.

When I got back to my home in Seattle, I looked for cute water bottles that maybe the kids would like. I found one online, it even had a carabiner on it! Who doesn't like carabiner? These were discontinued because the graphics were out of date. In April 2019, I again went to Villa Tunari, Bolivia with Smiles Forever, I took 75 of the water bottles to show the Smiles Forever people and to see where we might fit them in. I didn't bring all of them because they took up my whole suitcase and didn't have a solid plan. I had some suggestions like, "let's have the snack lady sell them with water" that was shot down because she might start putting the sugar water in them! Valid point. I wanted something good. It just didn't come to me or anyone else. I came home with no ideas on what to do. The sugar water was still in place and I had run out of ideas. The snack lady, was suspicious of what we were up to and she knew she is our target. In September of 2019, I was back in Villa Tunari, with a full suitcase of water bottles! I was set on finding a way to entice these kids to want water. Fourth times a charm! I thought, what if I bought all the sugar water from the lady, then she couldn't sell it and she would have her profit. Then pass out water bottles to all the children the Smiles people were seeing. Was told, bad idea and plus kids will just buy the other sugar stuff, like frozen sugar water pops. Now it's Friday, our last day and I have a suitcase of water bottles still. But then I thought, what if I traded, one of my bottles filled with bottled water for their sugar water. Would they think it's an even swap? So when recess started I took 6 water bottles and went out to find kids with the 'sugar water bags". Wasn't hard to find them. Sure enough they wanted the trade, I told each kid, only water can go in the bottle. I had written on the bottle, "water only" in Spanish. They understood, and they all traded. In fact, word got out and they all wanted to trade their "sugar water bags" and the ones that didn't have the sugar water went to the snack lady and bought a sugar water to trade for the water bottle. The snack lady couldn't keep up with demand, she didn't even tie the straw on the bags anymore, it was a free for all! I had found a way that the good water

Gaby making the trade! Children in town with their water bottles

bottles were better than the bad sugar water. The kids snapped the bottles on their belt loops, back packs anywhere they could as they loved the carabiners. Eventually the snack lady had no more sugar water but made her money, the children understand

the importance of water over sugar. (they saw us dump out the bags and throw it away.) We kept saying, you are not feeding the bugs anymore!

My Bolivia Experience

(Debby Cosier, BS, MA)

Debby Cosier and Dr. Steve Duffin.

In the summer of 2018 my neighbor Steve Duffin approached me to see if I was interested in accompanying him on his next trip to Bolivia. I had known Steve for years and was interested in his research with silver diamine fluoride (SDF). His trips to Ghana and Bolivia to work with children in remote areas where good dental care was nearly nonexistent sparked my curiosity. As a fellow health professional, I shared his goals and was surprised and delighted when he asked me to join him. As a community pharmacist I wasn't sure how I would be of help but was happy to try.

Upon arrival in Cochabamba we joined the team organized by Sandy Kemper of Smiles Forever. Her team consisted of dentists, a pediatrician/educator, and dental hygienists from Sandy's clinic as well as recent dental hygiene graduates from Seattle. We attended a conference put on at UPAL (Universidad Privada Abierta Latinoamericana) where we got a tour of the university and sat in on lectures over a 2-day period featuring talks by Steve, Karen Sokal-Gutierrez and Sharon Golightly covering SDF and childhood nutrition. The university clearly held the team in high regard and we were treated as honored guests.

We were then off to the town of Villa Tunari which is in a tropical area of Bolivia known as Chapare. Upon arrival, the team quickly set up operations in the classroom of a grade school. Chairs, tables, supplies, equipment—everything came together very quickly! This team had clearly worked together before and knew what they were doing. Soon thereafter, children were lined up to be seen. As they entered, their records were pulled, their height and weight was taken and they were assigned to a dental hygienist. Most of these children had been seen in the past, so notes were made as to any changes from previous visits. SDF was applied to tooth decay and followed by fluoride varnish. On a few occasions, teeth were extracted if the damage was extensive.

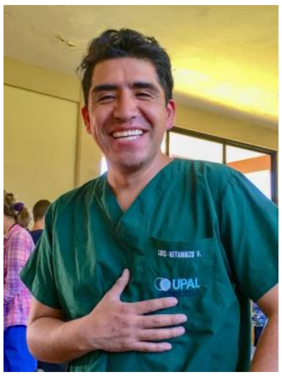
What was remarkable was the fact that these children had no fear associated with seeing a dentist because they did not associate these visits with pain. They were happy, played games, watched the clinic activities and had a great

rapport with the staff. Some of the staff were not fluent in Spanish, so the children enjoyed trying out their English.

While children were having their teeth treated, others were given dental hygiene lessons from the "Tooth fairies." Elise Tanner and 2 Bolivian hygienists dressed up in full fairy fashion and presented lessons to small children as well as high schoolers from a nearby school. We distributed toothbrushes and the fairies engaged animatedly with the students in proper brushing technique. I tried to help as best I could joining in with the children and demonstrating. These lessons took place several times a day throughout the week.

A class was held for the mothers as well. One of the big obstacles for oral health in Bolivia is the prevalence of sugary foods and drinks. These are sold in the school and are consumed by nearly every student every day. A presentation was given to educate the mothers in the role of diet in preventing tooth decay.

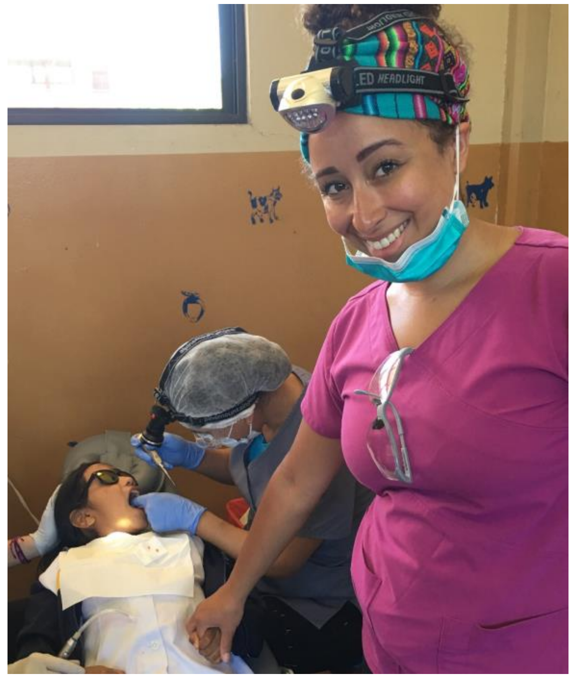
Dentists from UPAL came to visit for a few days, observing the process as well as participating in treating the children. They appeared to be impressed with what they saw. Support from UPAL is essential and seeing the Smiles Forever program in action helps in furthering the use of SDF.



Towards the end of our stay, I was given the opportunity to apply SDF to a few children. I had been observing throughout the week and I was curious to know if a layperson could apply SDF. It was essential that the hygienist or dentist check first for any signs of decay and indicate where the SDF was to be applied. Applying the compressed air to dry the tooth, prior to SDF application, took a light touch. Merely positioning my hand to apply the solution was awkward but certainly doable with some practice. On my second try, I used Dr Duffin's prototype device, an applicator, made by his company NoDK, which contains a measured dose of SDF in one end and fluoride varnish in the other. Each device is good for multiple applications. I found it a little difficult to apply the right amount of pressure to the device at first but could definitely see practical advantages in certain settings. I know Dr Duffin is hopeful that this protocol might be adopted by pharmacists, so he trained and introduced me to this protocol. My limited experience gave me an appreciation for what dental hygienists do! Although community pharmacists could not possibly conduct all of the duties of a hygienist, they would be able to be trained to apply SDF in a cost-effective program in remote areas such as Bolivia where dental care is unavailable.

At the end of the week, the children created posters promoting good diet and oral hygiene. Their efforts were creative and impressive, showing a good grasp of the concepts.

On our last day, the clinic was shut down and everything was packed up and put on the truck. Although work for most of us was done, records collected over the last few years still had to be organized for future data analysis to demonstrate the effectiveness of SDF. Throughout my stay in Bolivia, I was greatly impressed with the organization, skill and teamwork displayed by Sandy's group. They were highly professional, compassionate, and truly worked together as a team, taking over for each other and helping where needed. It was an honor to play even a small part of this program.



The Story of the Barron Mission

(Dr. Kurt Ferré, DDS)

Located in the Mexican state of Sinaloa is the small town of Barron, located 20 miles away from the major city of Mazatlán. Only 2 miles away from Barron is a beautiful resort, Estrella del Mar (EDM), which overlooks the Pacific Ocean.

The residents of EDM are mostly ex-patriots from the United States and Canada who spend 1 - 5 months away from the cool/frigid weather of late Fall, Winter, and early Spring. Many of the adults from nearby Barron have found employment in the many service jobs available at EDM.

The Children of Barron.

Claire Silk, RDH and student.

Barron is typical of many small communities in Mexico: low-income/poor, no physicians, no dentists, no pharmacy, poor infrastructure, including no potable water. The few local stores can be compared to those convenience stores in the United States that sell soda pop, and high sugar, low nutritious junk food. Many families cannot afford bus fare for their children to attend high school in Mazatlán, prohibiting students from attending school past the 8th grade.

In February 2006 a resident of EDM, Dale Lyster, decided to give back to Barron and started a non-profit organization called "Friends of Barron" (FOB, "Los Amigos de Barron"). Many projects have been created, some as simple as providing scholarships for bus fare to eager students to continue their education.

Most of the early projects were at the elementary school. The classrooms were originally situated around a square of an uncovered, dirt quad, measuring 120' x 120'. This quad is where the children would play. It was very hot, dusty, and if it rained, the area became a mud bowl. A local wealthy farmer paid

to have the entire quad poured in concrete with a high covering overhead.

Dale Lyster, attended the unveiling of the new structure and was inspired to continue work on the school infrastructure. He was instrumental in building and equipping a new library and a new computer lab for the school. During the dedication of the computer lab, one of the EDM residents, Claire Silk, a retired dental hygienist from Colorado, noticed the poor state of oral health of most of the children. She spoke to several friends involved with the FOB, and she suggested that they start a dental program for the students, who are in the first to sixth grades. She reached out to a hygienist friend in Denver, Deborah Astroth, and they came up with a plan of creating a dental team of 4 dentists and 4 hygienists who would come to EDM for one week and set up a dental clinic at the school. Every student would be screened, triaged, and treatment planned. The clinic would run from Monday to Friday.

I became involved, because my good friend from dental school, Dr. Jeff Astroth, is married to Deborah. A team was recruited, and the first clinic was planned for late September 2013. Volunteers were required to pay their own airfares and food expenses, but FOB provided free luxury condos at EDM.

What I remember from that first year was being overwhelmed with the amount of rampant cavities in many of the children. With only 2 portable dental units available, the amount of restorative work (fillings) that could be provided for the 190 students was limited. The percentage of kids with cavities within the six classes ranged from 60% to 90%. Asymptomatic baby teeth with a cavity were treated with fluoride varnish, and baby teeth with cavities that were causing pain and/or were abscessed had to be extracted. Our goal by the end of the week was to place sealants on the all permanent molars that didn't have cavities, fill the permanent molars that had cavities, and to place fluoride varnish on all the children's teeth. Several permanent molars had to be extracted because of abscesses, as there was no capacity to perform root canal treatment. The hygienists were invaluable in providing cleanings, fluoride varnish, and placing sealants.

That first year was met by much anxiety by the students and, to some degree, by the families and faculty of the school. Mothers were hovering, because, for many of the students, this was their first visit to the dentist.

The biggest disappointment was the number of teeth that had to be extracted. One of the main reasons for the baby teeth to remain until they naturally fall out is to hold space for the permanent teeth. When they are lost prematurely, especially for the baby molar teeth, space that is lost contributes to crowding of the permanent teeth later on. For the permanent teeth, losing a 6-year permanent molar, again, leads to tipping, future crowding, and loss of chewing ability.

Prevention was stressed, and the FOB did an excellent job of creating posters, and written material in Spanish to explain what the volunteer team was trying to accomplish. These posters were hung from the windows outside the classroom that served as the dental clinic. Also, provided were Spanish interpreters to help with communication.

One of the young men who volunteered to help run the dental clinic the first year was Jesus

Ibarra. He was born and raised in Barron, and learned English hanging around the golf course at EDM. He and his friends used to sell golf balls along the EDM/Barron boundary by the estuary and Jesus used his English skills to talk his way onto the course to play by befriending the golf pro. When EDM resident Dave Greiner donated his KP winnings, some $20,000 pesos, the golf pro organized a weekly golf clinic for the "Ninos del Rio. Jesus was so inspired by our team's work that first clinic, he applied and was accepted to dental school in Mazatlan. Two EDM residents cover the cost of his tuition and he is slated to graduate this year.

During the next several months, the FOB continued the dental education of the students in the classroom and provided an additional fluoride varnish application. The team also decided to move the next clinic to June of 2014.

The second year I arrived at EDM with a new addition to our team's armamentarium: a one-ounce bottle of 50% Silver Nitrate. I had learned about silver nitrate from a dental colleague in Oregon, Dr. Steve Duffin. Written about extensively in the early 20th Century by the "Father of Operative Dentistry", Dr. G. V. Black, silver nitrate can be applied directly to an active, growing cavity. The silver in the solution is an antimicrobial, meaning that it kills all the bacteria (germs) in the cavity and arrests the progression of it. Applied twice within one week, the lesion will become hard to touch. The only downside is that it will turn the cavity color from brown to black. A note written in Spanish (for the parents) was developed and sent home with each student, explaining this treatment.

This treatment is called the "medical management of cavities" (MMC), and comes with a basic understanding that filling cavities and treating oral disease (cavities) are not necessarily the same thing. By changing the content of the oral bacteria of these children's mouths, killing off the most pathogenic, cavity-causing bacteria, we would be reducing the susceptibility for future cavities in the children. However, for whatever reason, the use of silver nitrate fell out of favor in the mid-20th Century, only to be rediscovered in the early 21st Century as an important public health tool. Dr. Duffin has been credited for being one of the primary promoters of MMC in the United States and beyond, and he has traveled to Ecuador, bringing MMC to the public health dental clinics throughout that country.

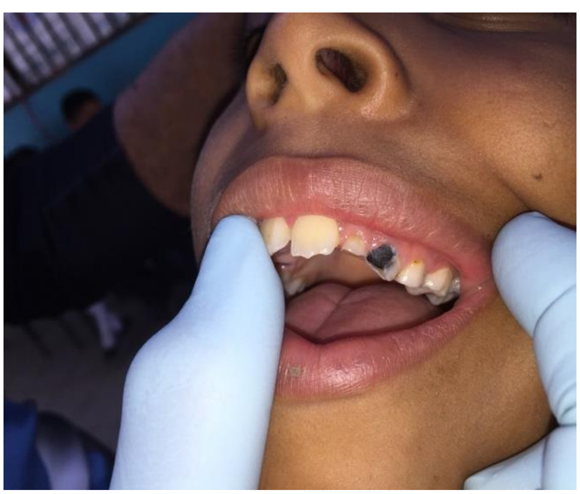
The members of the dental team were very excited, knowing that they could have a greater impact with the oral health of the children, again, having only one week to provide care. We also reversed the order of the classes seen last year, beginning with the 1st graders and progressing to the 6th graders. We did this change, because the baby teeth must last the longest before they fall out at their normal times. The 5th and 6th graders already have lost many or most of their baby teeth.

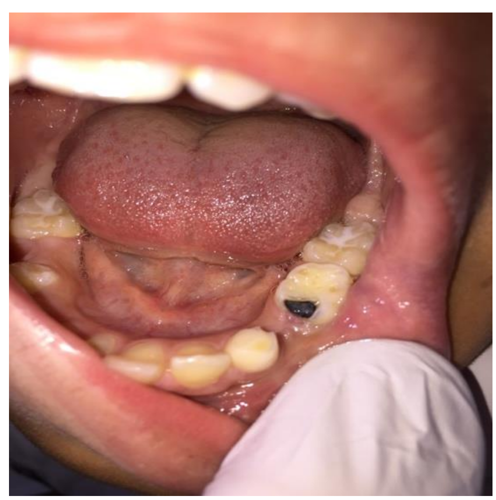
I had sent out information on silver nitrate to all the team members before they arrived at ESM, and I gave them a short in-service demonstration of its use before the first clinic. Several cavities can be treated with only one drop, and after each tooth is treated, fluoride varnish is applied over it. The varnish is used for 2 reasons: 1) the silver has a metallic taste and the flavored varnish negates it; and 2) it helps keep the silver nitrate in close contact with the cavity. Normally, one would have to, not only isolate and dry each corner of the patient's mouth when applying the silver nitrate, but also keep the area isolated for up to one minute after application in order for the silver to be effective. Therefore, our team members could treat each patient more efficiently, not having to wait as long between treating each area of a patient's mouth.

It should be noted that the dental hygienists were equal partners in applying silver nitrate, and the whole team felt increased confidence that by medically managing the cavities in baby teeth, these treated teeth, blacken cavities and all, would remain in the children's mouth, serving as space maintainers, and falling out at the appropriate times as the permanent teeth erupted in their mouths. It should also be noted that the parents, teachers, and students embraced the dental clinic to a greater degree this second year as compared to last year.

One of the new additions provided by the Mexican department of Education to the school was a new kitchen with modern, stainless steel appliances. Last year, the school cooks made school lunches for the students on an open-air, wood stove at the back of the school. Now, they had an indoor kitchen that could provide more variety in their lunches including more vegetables that required refrigeration. As a thank you to the dental team, lunch was provided to us by the school during each day of the clinic week.

We treated the same number of patients, but due to improved oral hygiene in the children and the oral hygiene visit with fluoride varnish application between clinic 1 and 2, there was less oral disease to deal with. However, there still were more extractions in both baby and permanent molars than we had hoped to see. The clinic did finish a half-day early, and the team was able to enjoy and participate in the children's singing, a game of musical chairs, and, best of all, a chant of "No mas azucar" (no more sugar), led by our local hygienist, Claire Silk. Several of the students also made thank you cards, which they presented to us on the final day. 2015 was the chosen for clinic #3. Then FOB won a $5000.00 grant from the Pierre





Example of dental caries successfully treated with Silver Nitrate.

Fauchard Academy Foundation, and a new ADEC mobile dental unit was purchased. The FOB started a tooth brushing contest the previous Fall, and the winner, a 6th grade female student, won a brand-new bicycle!

Everyone on the dental team was thrilled to see that the silver nitrate did exactly as expected. There were the asymptomatic baby teeth, especially the baby molars, with arrested cavities, remaining in the children's mouths until their normal time to exfoliate or fall out. This year was the first clinic that we didn't have to extract a permanent molar! There were fewer cavities, fewer fillings to be done, and better oral hygiene habits by the students.

Kris McGuire, FOB Administrator.

For the first time we were also able to go into the kindergarten, located in an off-site location from the elementary school and provide important preventative services: oral hygiene instruction to parents, teachers, and students, and every child received a fluoride varnish treatment. By reaching out to the kindergarten students, we could start the prevention and care a year earlier.

Even with this expansion, we finished a ½ day earlier than we did in 2014. None of the children in the elementary school had rampant cavities. This was definitely something to celebrate.

2016 was the chosen for clinic #4. What was the most notable observation were two students, one in 1st grade and another in 3rd grade that both presented with rampant cavities. What we found out was that both of these student's families had recently moved to Barron, and this was their first time to a dentist. We saw each of them multiple times during the week to treat their acute needs. Unfortunately, the kindergarten patient required several extractions. We are hopeful that at our next clinic scheduled in spring of 2017 we will see these two students with much better oral health.

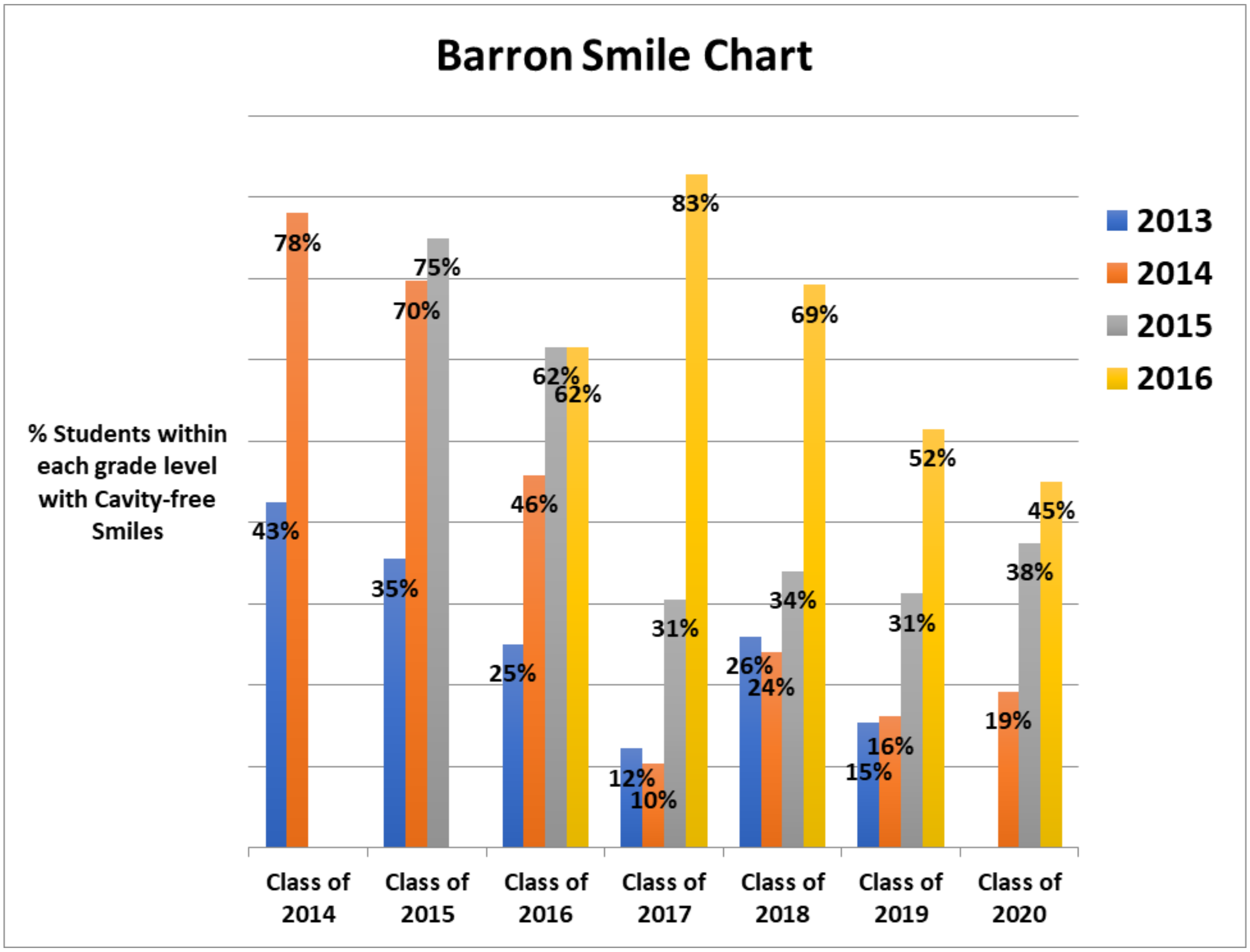
What is sad is the fact that there must be hundreds of impoverished rural communities in Mexico suffering from poor oral health.

Over the 4 years of the Barron dental mission, the other key member of the team who has been invaluable and incredibly generous is FOB member, Kris McGuire, a Colorado rancher. She has kept accurate records for each child we have treated from year to year and has tracked the progress and improvements in each class. While every class has improved their oral health status, the original 2nd grade class stands out. In 2013, 12% of the class was cavity free. In 2016, now 5th graders, 83% of the class is cavity-free!

In conclusion, there are 3 important factors in order to have healthy teeth, and I use the acronym, E.P.A: Education, Prevention, and Access to Care. With only a one-week clinic each year, the true lesson here is the importance of education and the use of every preventative tool that we have available. The impact that fluoride varnish and silver nitrate has had on the children's teeth has been remarkable. The principal, Jesus Gonzales has been so impressed that he wants our dental team to take this clinic concept to the Mexican Ministry of Health in order to duplicate this model for dental public health intervention, led by their own native dentists.

With Barron's native son, Jesus Ibarra, graduating from dental school in 2017, our hope is that our current team of volunteers will eventually work ourselves out of a job as we pass the torch to Jesus to continue the successes of the Barron dental mission.

Dr. Ferré and the friends of Barron dental team.


Barron Smile Chart
% Students within each grade level with Cavity-free Smiles
2013
2014
2015
2016
43%
78%
35%
70%
75%
25%
46%
62%
62%
12%
10%
31%
83%
26%
24%
34%
69%
15%
16%
31%
52%
19%
38%
45%
Class of 2014
Class of 2015
Class of 2016
Class of 2017
Class of 2018
Class of 2019
Class of 2020

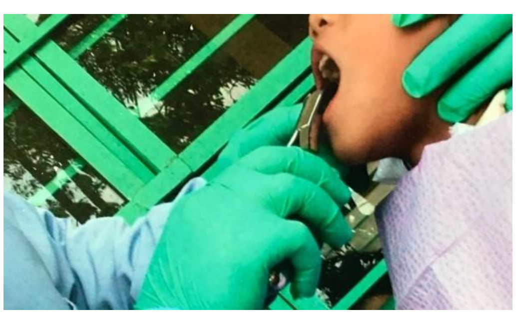
Treating Tooth Decay in Vietnam

(Dr. Ralph Duffin, DDS)

Dr. Ralph Duffin working in Vietnam.

During the years 2006 and 2007, the dental office where I practiced, volunteered to do a humanitarian mission to Vietnam. We were gone for two weeks each year. Myself and our support staff at our own expense, traveled to Vietnam to administer emergency dental extractions for young school age children.

We met with Le Ly Hayslip who was the author of the book Between Heaven and Earth, which was made into a Hollywood movie by director Oliver Stone. Le Ly took us to a country school each day, where we would see over 100 children. Our only treatment would be to extract abscessed teeth. Very few children were not in a state of advanced dental deterioration and experiencing daily pain.



As I examined the children if I identified abscessed teeth, local anesthesia was administered, and they were sent to a waiting area. When there were eight to ten children in this area, we stopped doing exams and extractions began. After the extractions were completed ,the children were sent to a recovery area. Then the examination line began again. There was just no way that we had the time and resources to treat the decayed but not yet abscessed teeth.

The post war economy has made soft drinks and candy widely available but difficult to combat their negative effects on the teeth.

Now we know that the early application of silver nitrate to a carious lesion will kill the bacteria and halt the decay process.

How I wish that I could have seen these beautiful children a few years earlier and prevented all of the trauma of surgery by the simple application of silver nitrate. Also while many of these people may not have been able to afford the placement of numerous dental restorations, the arrest of the progression of dental caries with silver nitrate is simple, inexpensive and painless.

It is interesting that while I was in dental school at the University of Washington in the mid 1950's, we were taught that silver nitrate kills bacteria. However, we were not taught an aggressive caries prevention program.

With this limited background I did treat young children with silver nitrate during the 1960's. I would apply it to 2 and 3-year-old children and then wait a couple of years to restore the teeth with fillings after arrest. Over time my practice evolved from treating children to focusing on older adults. So, I dropped out of silver nitrate use for a while.

Then one day an 85-year-old lady came to see me. She only had two teeth left in her mouth, both were lower canines. Both teeth had crowns and supported a lower partial denture. The tissue had receded and there was significant decay around both teeth at the crown margins. Customary treatment would have been to place two new crows and a new partial denture. In her world this was economically not possible. So, the practical option was to place some silver nitrate on the decay under the crowns. We applied several times over a couple of weeks until the decay was dark and hard. With enhanced tooth brushing habits, she is good for the rest of her life.

Dental decay is the most prevalent bacterial human disease in the world, effecting more people than any other infectious disease.

Studies extending from the 1880's to the present time have shown that silver nitrate stops most dental decay. So, let us find a way to promote a cure rather than treat the effects of this disease.

Improving Children's Oral Health: Bridging the Divide between Dentistry, Medicine and Public Health

(Dr. Karen Sokal-Gutierrez, MD, MPH)

I would like to offer my perspective – as a U.S-based public health physician and non-dentist - on what I have learned about children's oral health globally.

During my own childhood in a northeastern U.S. suburb, I didn't worry much about my teeth. My parents fed me healthy food and occasional sweet snacks, and helped me brush my teeth every day. They took me to the dentist every year for check-ups. Our community water supply became fluoridated later. I had some small dental cavities, and got them drilled and filled, but I never suffered from dental pain or any other oral health problem. On the contrary, people told me that I had a "nice smile," and my oral health contributed positively to my self-esteem.

After completing college in the 1970s, I began my professional career as a Peace Corps volunteer working in community health in rural Ecuador for two years. The families in the community ate straight from their farms – fresh vegetables, fruit, milk, eggs and meat, and only rarely consumed sweets or soda. The children had nice smiles too, and I didn't know any children there who suffered from serious dental problems.

Dr. Karen Sokal-Gutierrez in Ecuador.

In the 1980s, I completed medical school in California and specialized in pediatrics and preventive medicine. I was taught to do an oral exam including the lips, buccal mucosa, salivary glands, gums, palate, uvula, tonsils and pharynx; and I learned to diagnose and treat many diseases with oral signs and symptoms. However, I was never taught to examine children's teeth or diagnose dental problems. I don't know why - Maybe there was an assumption that children's teeth were naturally healthy, as doctors we didn't need to worry about the teeth because they didn't affect a child's health, or that it was the dentists' job not the doctors to examine, diagnose and treat children's teeth. Subsequently, I completed a Master's in Public Health program in maternal and child health, and there was no mention of oral health as a public health issue.

In the early 2000s, however, when I returned to work in Latin America, I was shocked to see widespread, rampant caries in the majority of the young children.

Dr. Karen Sokal-Gutierrez in Latin America in early 2000's.

I asked everyone, "What is happening here?" The grandparents explained that the children preferred junk food over their traditional foods; parents reported that their children had so much dental pain that they couldn't eat, sleep, play, and concentrate in school; doctors and community health workers acknowledged that the children were suffering from mouth pain and malnutrition, but they didn't know what they could do about it; and dentists said that they tried to help by bringing toothbrushes into the elementary schools. It was clear to me that this wasn't "just a dental problem," but it was a dramatic change in the culture with adverse impacts on children's nutrition, quality of life, educational potential and economic future. Early childhood tooth decay appeared to be a widespread and severe health problem that was getting too little attention too late.

Since then, I have focused on filling the gap in my medical and public health education by learning as much as possible about the pathophysiology and epidemiology of early childhood caries. I learned about the multifactorial causes of tooth decay including the cariogenic bacteria metabolizing sugar in the diet, and the disparities in oral health between different populations. I observed firsthand the main driver of early childhood caries pandemic – the marketing to parents and young children of low-cost processed and sugary snacks and drinks which has led to a "nutrition transition" in low- and middle-income countries from the traditional whole-food diet to the modern processed and cariogenic diet. I learned about the strong connection between oral health and overall physical and mental health, and that poor oral health and chronic oral inflammation can cause substantial oral pain and poor quality of life, contribute to substance abuse, preterm delivery, and exacerbate chronic diseases such as asthma and diabetes.

In our research studies on children's nutrition and oral health in El Salvador, Ecuador, Vietnam, Nepal and India, we have found similar patterns of behavior and disease. Starting in the first two years of life, most children are consuming sweet snacks and drinks on a daily basis – junk food has become a daily staple of children's diets. Tooth decay is also beginning in the first two years of life, increasing in prevalence and severity to affect over 90% of children by age 6, and leading to severe consequences including mouth pain, difficulty eating, and poor school performance. Children with severe tooth decay are more likely to experience malnutrition (typically in low-income countries) or obesity (typically in high-income countries) with associated risks for type 2 diabetes, cardiovascular disease and other non-communicable diseases (NCDs). And over 90% of the tooth decay globally remains untreated due to low prioritization of oral health at the government health services level, lack of public oral health education, widespread fears of dental treatment, limited numbers and poor distribution of dentists, substantial distance to clinics, long transportation time and clinic waits, and costs for transportation and treatment. Due to the barriers to dental care, approximately half of the children as well as their parents suffer from ongoing oral complaints (e.g., decayed, broken and loose teeth, dental abscesses, inflamed and bleeding gums, and mouth pain), and they generally delay treatment until the oral disease is advanced and the pain is unbearable. Usually, the treatment is extraction rather than preservation of the teeth.

On the positive side, we know that dental caries is preventable by reducing sugar consumption, brushing teeth daily with fluoride toothpaste, and applying periodic fluoride varnish; and easily treatable with non-invasive dental treatments such as silver-modified atraumatic restorative treatment (SMART). And in the low-resource sites where children and adults have suffered from poor access to dental care, most have successfully accessed public health and primary care medical services – over 90% reported that they received prenatal care and child immunizations. This got me thinking that we could expand access to dental care by utilizing the effective public health and primary care

medical infrastructure, particularly maternal and child health services.
Since the early 2000's, the American Academy of Pediatrics (AAP) has been a medical leader embracing oral health as an important child health issue. AAP has developed protocols for oral health interventions in pediatric clinics at the frequent well-child visits beginning in infancy: providing oral health guidance, oral health risk assessment, dental screening, fluoride varnish application, and referral to dentists. The AAP Section on Oral Health has provided online and onsite trainings for pediatricians, multilingual educational materials for parents on oral health, and grants for pediatricians to develop their oral health services (link AAP section on oral health). I believe that child healthcare providers could build on our current services to do even more – we could be trained to provide SMART treatment, particularly since we see children frequently in early childhood when caries can be arrested before it progresses to complications. And we need to spread this model of incorporating oral health into medical practices globally.

Over the past decade, I have been working to increase the awareness of oral health among physicians and public health professionals. I have observed that oral health is still not generally included in medical and public health curricula in the U.S. and globally, and most medical providers and public health programs do not address oral health. For example, while parents of children with severe caries say that their child's mouth pain interferes with their eating, sleeping and contributes to their malnutrition and poor growth – and the relationship between poor oral health and malnutrition has been demonstrated in studies in children as well as in elders - global child health and nutrition experts have not yet recognized severe tooth decay as a cause of child malnutrition, nor preventing severe early childhood caries as a strategy to prevent malnutrition.

I believe that all children in the world deserve the benefits of prevention and prompt treatment for tooth decay to enable them to be pain-free, well-nourished, healthy and successful in school. To prevent tooth decay as well as malnutrition, obesity, diabetes and cardiovascular disease, we need to optimize healthy nutrition and reduce the common risk factors – the non-nutritious, processed and sugary snacks and beverages. We need to work together globally, across professions, to develop a clear and consistent focus on nutrition and oral health, prevention and treatment, and policies and clinical interventions with an "upstream" focus from the youngest ages – pregnant women and young children. Some strategies include:

- Promoting inter-professional education and collaboration, making oral health part of medical and public health education, and integrating early childhood caries prevention and intervention into primary care maternal-child health services and childcare/preschools.

- Educating families and children regarding strategies for improving child nutrition (e.g., promoting breastfeeding and whole foods, and limiting bottle feeding and non-nutritious processed and sugary snacks and beverages); and encouraging daily physical activity and daily toothbrushing with fluoridated toothpaste, at home and at school.

- Implementing governmental and school policies to ensure healthy environments for children. This includes prohibiting marketing of non-nutritious and sugary snacks and beverages to children, especially in and around schools; taxing unhealthy products such as sugar-sweetened beverage and snacks; and "making the healthy choice the easiest choice" by providing free and low-cost access to potable water and healthy snacks in schools and communities.

- Ensuring universal health care that includes medical and dental visits, for prevention and treatment. The health care system should incentivize health care providers to ensure early lower-cost preventive care and reduce the need for higher-cost therapeutic care. Medical and dental visits should include attention to nutrition and oral health including clear health promotion messages, nutrition and oral health screening (including brief diet history, height and weight, and dental/oral exam), tailored nutrition and oral health counseling and support, preventive application of fluoride varnish and/or silver diamine fluoride, and referral to additional nutrition and oral health resources as needed.

As a representative of the medical and public health professions, I strongly believe that we must "bring the mouth back into the body," and incorporate nutrition and oral health into our public health and primary medical care services, as well as local and global health policies.

Dr. Karen Sokal-Gutierrez in Villa Tunari, Bolivia in September of 2018.

In September of 2018 I participated in a SMART dental outreach program in Villa Tunari Bolivia conducted by the Smiles Forever Foundation.

Silver Diamine Fluoride in a Cambodian Primary School Context

(Dr. Bethy Turton, BDS, MComDent, PhD)

Children in Cambodia have a severe burden of dental caries especially affecting the primary teeth. The average 6-year-old Cambodian child has 9 cavitated teeth and 2.7 pulpally involved teeth. In the presence of this severe disease experience, 99% of carious lesions are untreated. If the conventional treatment approach to address these problems (eg "drilling and filling" and extractions) was implemented, the costs would be more than the national health budget for Cambodia, and the whole dental workforce of Cambodia could still not provide all the treatment needed. Even then, such an approach would not reduce the incident burden of disease because the conventional model of care does not address the social and behavior drivers of the disease.

The key goal of the Healthy Kids Cambodia project is to model the delivery of primary health care services in a Cambodian school environment. The lead organization is a local Non-governmental Organization called 'One-2-One Cambodia' and they have been providing dental treatment for hard to reach groups since 2008. In the beginning, the service was simply discrete mobile clinics organized in the contexts of schools, communities, and prisons. However, it became very evident that these one-off trips (even when repeated) did very little to make a lasting change in the quality of life of the participating children. Furthermore, that model of care, which could be coined as 'parachute dentistry' undermined trust in local practitioners. It was disproportionally expensive compared to the work that was completed and it created a perception among communities that dentistry was primarily the business of pulling out teeth. In that model, there was much less space for preventive care, and there was very little opportunity to mobilize or empower communities to undertake preventive action for themselves.

After exercising the parachute dentistry model, the next step that One-2-One took was to employ the SEAL Cambodia model. In the SEAL Cambodia model, One-2-One Cambodia program and its partners totally re-orientated the care towards a single intervention (Glass Ionomer Cement Fissure sealants) for 60,000 6- to 8-year-old children. The SEAL Cambodia project provided a valid training ground for a prevention-focused model for delivery of care. That project allowed the network to test a large-scale dental activity and to build partnerships across Non-Governmental Organizations, Dental Schools, Primary schools, and Government departments. The problem with that model was that the preventive increment went from 90% at one year to 30% at two years after one in five children among the group developed interproximal lesions on first permanent molars. While the intervention did reduce lesions initiated on the occlusal surfaces of first permanent molars, the intervention was not sufficient to holistically manage the caries process.

The Healthy Kids Cambodia (HKC) strategy built on these described experiences to create a graduated approach to applying preventive health strategies and dental treatment so that resources would be able to reach a larger number of children and those children who needed it would be able to receive intensive oral rehabilitation. The HKC strategy recognizes caries as a social and behaviorally driven disease that cannot be addressed by biomedical interventions alone. Therefore, a key part of setting up the intervention is to attempt to map out and then to mobilize the social structures that surround a school so that the child has the best chance of encountering a healthy environment where the caries disease process can be managed. The school environment provides a unique opportunity to demonstrate a healthy physical and social environment and it provides an opportunity for repeated exposures to health interventions.

The HKC project is an outworking of existing School Health Department policies along with the graduated delivery of health interventions at three levels using a validated set of triage criteria (Table below). The partner organizations represent the NGO sector, the academic sector, and the government bureaus of both Oral Health and School Health. The care providers are mostly Cambodian dentists and dental students, Dental Nurses (similar to a dental therapist) and school nurses. Visiting volunteer dentists and dental students, and Bachelor of Oral Health Students also participate along with Cambodian providers

The three-tiered system used to triage children based on epidemiological indicators of disease experience

Referral	Triage Criteria	Treatments
Level 1	All participants	Daily tooth brushing with fluoridated toothpaste and hand washing. Biannual basic health screening, de-worming, Vitamin A and silver diamine fluoride to arrest caries in primary teeth
Level 2[a]	Children 6-to 8-years of age OR those who have open cavitation's on permanent posterior teeth	Placement of Atraumatic Restorative Technique (ART) restorations and pit and fissure sealants
Level 3[a]	Children with active infection OR those who have open cavitation on permanent anterior teeth OR those who have cavitation's on permanent posterior teeth that are not restorable by ART	Comprehensive oral rehabilitation in the conventional dental setting

Children may qualify both level 2 and level 3 depending on their clinical presentation.

at varying levels depending on the needs of the community. Allocation of the workforce and resources is informed by an online database system.

A child with an active dental abscess will be immediately referred for relief of pain (less than 5% of children at first screening) but other lesions are left to be managed at higher levels of care. Around 40% of children require Level 2 care and approximately 20% of children require Level 3 care. This triage system is in contrast to conventional practice whereby triage is performed by dentists at tooth level and extraction dentistry dominates the allocation of resources leading to hap-hazard application of preventive therapies.

The Special Role of Silver Diamine Fluoride (SDF) in the HKC strategy

In the case of HKC, silver treatments are viewed as the best first step to slowing down the caries process among a population where the disease is ubiquitously severe. The SDF makes it possible to deploy a 'reverse triage' system whereby the bulk of the lesions (except for lesions on permanent anterior teeth) are managed with SDF at the time of screening. That means that SDF treatment happens after the implementation of daily tooth brushing in schools and before the delivery of more invasive care for those who need it.

In the HKC strategy we have found that approximately 50-60% of the primary school children can be managed with tooth brushing and SDF alone. this frees up resources to place ART sealants and restorations for the 40% that benefit from those minimally invasive procedures as well as provide complex rehabilitation for the most severe 20% who meet the criteria for level 3 care.

We have been able to validate the role of SDF as preventing the incidence of dental infection and reducing restorative need. The restorative workload required at level 2 and level 3 halves after 1-year of the project. As of April 2018, the project had up-scaled to 12 partner organizations and around 12,000 children who received SDF 1-2 times per year together with oral health education and daily tooth brushing with fluoride toothpaste. During the 2017-2018 academic year, 9,865 GIC fissure sealants were placed, 1,623 ART restorations were placed and nearly 1,500 children have received comprehensive full mouth rehabilitations that would not have been possible had the resources been diverted to manage lesions that have now been managed with SDF. This number of participants in the project is expected to grow to around 20,000 by the end of 2019.

A View to the Future

Ongoing activities are focused on validating the interventions for the Cambodian context and as well as exploring avenues for advocacy. We think that Level 1 of the HKC strategy should become the minimum standard of care for children attending public schools in Cambodia. The HKC strategy has a long way to go in terms of advocating and for structural change so that the power to manage the caries process can be transferred back to the participating communities. We would like to see communities mobilized to demand better food quality in schools. We would like to see the children entering the Healthy Kids Program with a lower burden of diseases because the accompanying health centers have initiated preventive interventions from birth. We would like to see the project become sustainable through adoption by government agencies. In the meantime, SDF is an essential tool in managing the symptoms of the caries disease in schools across Cambodia.

Students from the university of puthisastra provide SDF treatment for 1200 children in one public primary school.

A young child receives SDF treatment at a one-2-one 'healthy kids' mobile clinic.

Dr. Bethy Turton works with students to perform a clinical audit of treatment provided through the HKC program at a school in Phnom Penh.

Oral health education is being provided by a dental student from the University of Puthisastra.

Silver Products to Arrest Decay in the Tribal Northwest

(Dr. R. Anthony Bass, DMD)

In 2011, I accepted a position as Dental Chief at the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) near Pendleton in northeast Oregon. Nestled near the foothills of the Blue Mountains, the reservation sits on some of the most picturesque country an outdoorsman could want. Their Yellowhawk Tribal Health Center (YTHC) provides ambulatory health care for the Umatilla, Walla Walla and Cayuse tribes as well as Native Americans and Alaskan Natives from other tribes .

With nearly three decades of dental experience, I had seen quite a bit. However, this would be my first job working specifically for Native Americans. Steeped in traditions, I found them to be warm and appreciative. There were disparities in decay rates between the tribe and "Mainstream America" but not as dramatic as rumored.

Caries rates were on the rise nation-wide, not just in "Indian country". Realizing that we couldn't "drill and fill" our way out of this problem, another solution or solutions had to be implemented.

Being that we were a Tribal facility and not under the complete control of the Indian Health Service (IHS) we had some latitude in what methods and treatment modalities we employed. The IHS did have recommendations and guidelines for us to use but we were not limited by those.

Although we were not an IHS facility, we did participate in their data gathering. The three metrics that IHS had been monitoring for many years were: Access to Care, Sealants and Fluoride Applications. The IHS refers to these as GPRA numbers (for Government Performance and Reporting Act.) These measures are used as an audit of prevention efforts by clinics that receive Government funding. Recognized as effective caries prevention methods, we used these along with Home Care Instruction, Xylitol products and a variety of others. We were hitting our GPRA numbers and, still, we were seeing far too much new and recurrent decay and sending too many kids to the pediatric dentists.

Most of the children referred were taken to the hospital and treated under general anesthesia (GA).

For several reasons we were not content with this outcome. There was the needless suffering of the children with symptomatic and abscessed teeth. Being that we were in a rural location, their families had to drive a significant distance to the specialist and take more time off work. Emerging evidence that GA was not good for the developing brains of children was gaining more attention. Furthermore the clinic budget could not sustain the rates of these referrals. Money for referrals drained funds that could be used for other treatment and preventive efforts.

More dentists were hired with pediatric dental skills allowing more children to be treated in-house. But still we seemed to be falling behind the demand for dental care.

Having worked in a myriad of dental delivery methods, I knew that those systems did not hold the answer to this burgeoning problem. Some groups had tried to create or modify prevention and treatment protocols with limited success. Not being a stellar researcher, I relied on word of mouth and contacted Dr. Gary Allen from Advantage Dental Care in Oregon. Dr. Allen and I had previously worked together for several years with another group. He has a background in pathology and I trusted his judgment. He spoke of various products and prevention techniques, some I had heard of and others not. When he described the silver nitrate/fluoride varnish protocol (SN/FV) it piqued my curiosity. He recommended that I speak with Dr. Steven Duffin, a private practice dentist that has a background in microbiology. Dr. Duffin had been using it for years and had collected data on his results. SN/FV was safe and simple to use and it "arrested" decay. "Arrest" was a foreign term to me and many other dental professionals at the time.

Dr. Duffin and others from Advantage Dental Group were invited to visit our clinic. Dr. Duffin gave a presentation to dental staff as well as YTHC administration and members from other departments in the health center.

The biochemical action of SN/FV was described. This protocol causes the decay to harden and become arrested. It has a storied history of use over a hundred years before by the "Father of Modern Dentistry," Dr. G. V. Black, was impressive. Dr. Duffin explained that it was approved for soft tissue use in the mouth by the FDA and that he and others were using it "off label or caries treatment." After his presentation, I was cautiously optimistic but still a little skeptical. It sounded a little too good to be true.

Members of the YTHC administration, also impressed with Dr. Duffin's message, recommended that I first seek approval of the Tribal Health Committee (HC) before implementing a SN/FV program.

I had heard Tribal elders relay stories of the "bad old days" of dental care on the "Rez". Once or twice a month, a government assigned dentist would show up at the single-wide trailer that served as a dental clinic. People from the reservation would line up outside awaiting their turn. Occasionally, a filling would be done but most of the time the treatment was extraction. Recollections varied but they had a common theme. Most of the time, it was brutal. "We want better for our children and grandchildren." So, I wanted to do this right.

I would have to demonstrate that the product was safe, effective and that their children would "not be used as guinea pigs." Of necessity, I became a researcher looking for more information, studies and data about this silver nitrate product. The more I dug the more I became convinced this was the right thing to do. Many of the articles and studies found were from overseas. Although their methods, protocols and outcomes varied, their basic message was the same. Silver products do work to safely arrest tooth decay.

When presented with this information, the HC voted unanimously to approve the use of SN/FV.

They recognized the need. Their only request was an occasional report on how well the SN/FV program was working.

With the green light in place, an information sheet was drafted complete with a picture of arrested decay on the cavitated lesion in the occlusal of a primary molar. The sheet helped inform the parents/guardians about this new option to treat their child's decay. This was key to gaining Informed Consent. Most were pleased that it did not involve shots or drilling or driving 75 miles to the specialist for treatment with G.A. Some were understandably reluctant to give consent because it involved turning the decay black. This was especially concerning when a front tooth was involved. Others had a difficult time getting the kids to the office for the 4-5 applications (using 25% $AgNO_3$) and reassessment.

Since we were working for a "sovereign nation" we were not obligated to follow the exact ruling of the state. Certainly, we were bound to provide safe and ethical care for our patients. Therefore we didn't want to stray too far afield of the state laws since we relied on them for our licenses to practice dentistry.

But several states at that time, including ours, were embroiled in controversy about this treatment modality. Silver nitrate and silver diamine fluoride (SDF) had become political hot potatoes in the dental world. Even so, some providers in the US had been using silver products clandestinely (but safely) for years. It had not yet acquired a "best practice" designation. Nor did their use or the arresting of decay have an ADA code at that time. Those of us who were using it were labeled mavericks or cowboys by those who were opposed. One member of the board of dentistry was a pediatric dentist. It would be understandable for him to feel threatened by something so simple that could affect his livelihood. While another member of the board reached out to me and asked for information about our program without prejudice.

The protocol that we adopted involved, on the first appointment, the dentist discussing with the parent/guardian, getting informed consent to use SN/FV and applying it that same appointment. The last application was done by the dentist but also doing an assessment to determine how well the spots of treated caries were arresting. The intervening applications were done by the dental hygienist or the expanded function dental assistants (EFDA's).

This was also another point of controversy. While debate was going on about whether these products should be allowed at all, we were allowing non-doctors to do the applications. (What an outrage!) My thought was that there was no greater safety threat applying SN/FV products than there was applying the acid etchant used for sealants. With a modicum of training, the assistants and hygienists could safely apply these products based on the dentist's treatment plan. Safety glasses for patients and staff were employed as with any

procedure. Staff would inquire about any negative events or symptoms experienced by the patients and inform the dentist.

We tracked our results, not only for our own curiosity but to have information to show the HC about the progress of this program. We wanted to know if we needed to alter the protocol we had learned from Dr. Duffin or alter our application technique.

In 2013, after implementing this treatment for just 1.5 years, I was invited to present our findings at the Symposium on Caries in the Primary Dentition in American Indian and Alaska Native Children. Our numbers were not as impressive as those from other clinics using the same medicaments. But we did see that 50 % of the carious surfaces treated were arrested. And this was more than we had arrested before. With a review of our technique and reporting methods, our results improved. And most importantly, we could report that it was safe. Aside from an occasional transient staining of the adjacent gingiva or tongue and complaint of bitter taste, there were no adverse reactions reported.

The learning curve included some stained counter tops from spills while dispensing into dappen dishes. Stained scrubs and fingertips occurred also. Once the follow up report was given to our HC, our tracking of individual arrested carious surfaces ended. We still tracked the number of applications on our EDR, Dentrix Enterprise. But there was no need to prove anything anymore. We knew it worked.

Shortly before my departure from YTHC in June 2017, we switched from SN/FV to 38% Silver Diamine Fluoride. We found there was caries arrest with fewer applications. This lead to better compliance and more completed treatment.

With our limited clinical study, we knew we were not going to unlock the secret to the best protocol for silver products to arrest decay. But I would like to think that we helped to shine a light on the subject along with providing our patients another caries treatment alternative.

In June 2017, I moved northward. As of this writing, I am the Dental Director of the Dena'ina Wellness Center (DWC) in Kenai , Alaska. The center provides similar services to their ***un'ina*** (pronounced ***oo-nee'-na***, a Kenaitze Indian word that means "those who come to us" or "invited guests") in an ambulatory setting as does YTHC. Their Tribal facility is just a few blocks from the world-famous Kenai river (ask any fisherman) next to the Cook Inlet in south central Alaska.

Silver products already have had greater acceptance here. They have been used in other Indian health centers and remote village clinics for years. So when I asked to introduce SDF, there was no pushback. But I shared with the staff the lessons learned previously.

Lessons Learned

1) Silver products are not a panacea. They do have limitations.
    a) The arresting effect on caries by SDF and SN/FV can be overwhelmed by poor diet and inadequate oral hygiene.
    b) Even so, they can slow the decay process even if complete caries arrest is not achieved.

2) They do require complete understanding by the parent/guardian (informed consent).
    a) You do not want to surprise a parent or patient with black spots on the teeth. You may have conquered the disease but lost a patient or at least their trust.

b) Restorative options should be discussed including the covering of the black spots that will lighten the darkness

3) They are technique sensitive.
   a) Moisture control, like with most dental procedures, is a key to success.
   b) Removal of food debris before placement might seem to be a "no-brainer" but is easy to miss in a squirming 3-year-old. If food debris remains during the application, then silver and fluoride cannot penetrate to the carious dentin.

4) With minimal training they can be safely and easily applied.
   a) As mentioned above, this is not rocket science. Following a few safety rules, it is no more difficult than when applying sealants or doing other similar procedures.

5) They are very inexpensive especially compared to the alternatives.
   a) Although SDF is more expensive than SN/FV, they both cost pennies per application compared to the thousands of dollars for a hospital visit for treatment under GA
   b) Parents need not drive to yet another location for their child's care.
   c) Money is saved for the facility to use for other purposes.

6) They are less traumatic than other treatments.
   a) No shots, less fear.
   b) When restorations are done, often they can be accomplished using a slow speed round bur and no anesthetic.

7) They do work.
   a) The limitations regard the "when" to apply and expectation of success. If the carious tooth is already symptomatic with irreversible pulpitis or abscessed, no amount of SN/FV or SDF is going to reverse that problem.
   b) The use of these products on permanent teeth has a place. I have used SN/FV on a limited number of elderly patients to control root caries. I treated a gentleman that resided in a nursing home that had many medical complications. He most likely would not have survived extractions. Arresting the decay was a reasonable way to manage his carious roots. Six months later he passed away, succumbing to his many ailments, without having to be traumatized with a surgical or restorative procedure.
   c) There exist mountains of data from many sources confirming the claims of successful arresting of decay. Prominent universities are now taking up the true research reviewing protocols for the use of silver products.

I will not attempt to make recommendations about when or not to restore arrested caries. Nor will I suggest which materials to use when restoration is needed. It seems that there are new protocols and products coming out nearly daily. And there are folks in the dental community that are far more informed about these changes. As with any restoration one must use the product and/or technique that works best in their hands for the best outcome. The best recommendation I can offer is to stay informed by reputable sources.

Now, there is an ADA code for the use of silver products to arrest caries and increasing acceptance by the dental community as a valid, non-surgical treatment method. My hope is that this review by a clinician will not only serve as a present-day historical explanation of *how we got here*, but as a reminder that change can be a good thing.

In the words of John Locke (1632-1704), English philosopher, physician and "Enlightenment Thinker",

"New opinions are always suspected, and usually opposed, without any other reason but because they are not already common."

Acknowledgements

I would like to extend a Thanks to several folks:

- To Dr. Gary Allen for making the connection.
- To Dr. Steven Duffin for paving the way and giving us the knowledge and tools.
- To Dr. Patrick Blahut (IHS retired) for protecting and guiding us during those early years of controversy.
- To my staff at Yellowhawk for tolerating my mania when things were difficult. And for accepting this new treatment method that had not yet received acceptance by the dental community. There was a risk.
- To the administration and Health Committee at YTHC for having the bravery to move forward for the sake of their kids.
- To my staff and administration at DWC dental for accepting the word of this newcomer about this new treatment modality.
- And to my family for also tolerating my mania (all the time)

Effects of Silver Nitrate on Oral Biofilm

(Monika Alcorn, RDH, MPH)

"It is with great pleasure that I introduce Monika Alcorn and material from her Masters' thesis published here. Monika has been an inspiration and major contributor to the development of MMC and SMART Dentistry for everyone. Her primary focus was on the effects of silver ion compounds on gingivitis as opposed to caries in this presentation."
S. Duffin

Introduction

Oral biofilm, commonly referred to as dental plaque, is quite complex in structure and harbors many microbes of varying pathogenicity. As the biofilm ages and moves subgingivally, the existing species become increasingly anaerobic and more pathogenic. Although these pathogens cause oral diseases, such as dental caries and periodontal disease, research has shown that their impact can go beyond that of the oral cavity and affect the overall systemic health of patients if the disease process is not halted (*Armitage, 2010*). In the case of dental caries and periodontal disease the most direct approach has been to remove the reservoir of pathogens, namely the biofilm. The removal of biofilm requires its physical disruption via a mechanical approach such as regular tooth brushing and professional debridement. Adjunctive use of antibiotics is frequently utilized to further reduce the subgingival populations of pathogenic bacteria. Unfortunately, there is evidence of a substantial increase of antibiotic resistant oral pathogens, making antibiotics less effective as adjunctive therapy (*Spacciapoli, Buxton, Rothstein, & Friden, 2001*). Therefore, more studies which specifically address the susceptibility of pathogens residing in multispecies biofilms to topically-applied antimicrobial agents are needed.

Silver and Silver Ions

Silver ions, within the silver nitrate solution ($AgNO_3$), have been credited with decreasing bacterial counts in oral lesions. Silver ions exert several mechanisms of antimicrobial action. They have an affinity to thiol groups (-SH), critical components of bacterial enzymes, disabling the production of energy due to interference with the cell's respiratory enzyme system (*Allaker, 2010*) (*Demling & DeSanti, 2001*) (*Feng et al., 2000*) (*Matsumura, Yoshikata, Kunisaki, & Tsuchido, 2003*) (*Silvestry-Rodriguez, Sicairos-Ruelas, Gerba, & Bright, 2007*). Silver also interferes with the bacterial cell's DNA by binding with the phosphate groups within the DNA, causing problems with replication (*Allaker,* *2010*) (*Feng et al., 2000*) (*Matsumura et al., 2003*) (*Clement & Jarrett, 1994*). Proteins within the bacteria can also become denatured as a result of treatment with silver particles (*Sondi & Salopek-Sondi, 2004*). Cell division is disrupted when the cell's DNA bases bind with the silver ions from silver nitrate. The hydrogen bonds between the nitrogenous pairs are displaced by the silver ions thereby inhibiting DNA replication (*Allaker, 2010*) (*Rai, Yadav et al., 2009*) (*Richards, 1981*) (*Russell & Hugo, 1994*) (*Silvestry-Rodriguez et al., 2007*). These mechanisms are shown to occur in many different bacterial species when exposed to sufficient levels of silver, the higher the concentration of silver particles, the greater the destruction to the bacterial cells (*Sondi & Salopek-Sondi, 2004*).

While most antibiotics damage specific sites on bacteria, this specificity allows the bacterial cell to adapt the susceptible site and become antibiotic-resistant. However, bacterial resistance to the effects of silver is more complicated because the metal interferes with a wide range of cell functions at the same time, making it more difficult for bacterial species to evolve at multiple sites simultaneously (*Rai, Yadav et al., 2009*). Bacterial cells are destroyed before they have time to adapt (*Allaker, 2010; Pal, Tak, & Song, 2007*). In vitro and in vivo studies have demonstrated the efficacy of silver in arresting active dental caries as well as in preventing new carious lesions (*Rosenblatt, Stamford, & Niederman, 2009*) (*Tan, 2006*) (*Tan, Lo, Dyson, Luo & Corbet, 2010*). Silver nitrate has historically been used to arrest caries and is currently used with dental patients in Oregon.

Silver, Dental Caries and Periodontal Disease

While many pathogens are opportunistic and cause infections on a systemic level, there are those pathogens that are ubiquitous and cause wounds on a much smaller scale, albeit no less problematic. Streptococcus mutans is the bacteria that has been implicated in causing dental caries, resulting in dental pain, loss of tooth structure, loss of oral function (eating, speaking, smiling), and reduction of self-esteem. On a global scale, 95% of humans have experienced this infectious disease (*Espinosa-Cristobal et al., 2009*), making dental caries the most common infectious disease on the planet.
As with many diseases, some populations experience a disproportionate incidence of this disease. Those of low income, low socioeconomic status, racial minorities, the infirmed, and rural populations carry the heaviest burden. It has been consistently found that 20% of the population has 80% of the dental caries (*Duffin, 2012*). Traditional, invasive restorative dentistry has failed to curtail this disease process. The secondary intervention nature of restorative dentistry attempts to repair the damage after it is well under way. Preventive measures have helped but have not come close to meeting its potential in thwarting the disease process (*Espinosa-Cristobal et al., 2009*). For treatment to be successful, the most common cause of dental caries, as well as periodontal disease, must address the presence of oral biofilm (*Addy, 1994*).

The bacterial species responsible for periodontal disease are different than those that cause dental caries. Some well-known periodontal pathogens include Aggregatibacter actinomycetemcomitans, Porphyromonas gingivalis (*Donlan & Costerton, 2002*) (*Mombelli, 2003*) (*Yilmaz, 2008*), and Tannerella forsythia (*Dorfer, 2003*) (*Li et al., 2004*) (*Marsh &

Bradshaw, 1997) (*Nibali et al., 2014*) (*Quirynen et al., 2003*) (*Socransky & Haffajee, 2002*) (*Trombelli & Tatakis, 2003*) (*Venezia & Shapira, 2003*). Treponema denticola, a virulent periodontal spirochete, is also frequently present in individuals with severe and/or refractory periodontitis (*Marttila et al., 2014*).

The effectiveness of silver ions against periodontal pathogens is unknown. Therefore, it is with this question in mind that the effectiveness of a limited application of silver nitrate was applied. This study sought to determine whether or not the silver ions in silver nitrate could decrease biofilm accumulation, prevent gingival inflammation, and demonstrate substantivity during a two-week period where no posterior dental homecare was performed.

Methods and Materials

The Human Subjects Committee at Idaho State University approved this study, # 4035. Prior to volunteer recruitment, thirty ampules were filled and sealed with either 20 µL of saline solution (control group) or 20 µL of 25% silver nitrate (treatment group), resulting in 15 ampules for each group. The ampules were created and numbered by a microbiologist. Only the microbiologist knew which ampules contained which solution. All the volunteers and the principal investigator (PI) were blinded as to who received which solution until after the data gathering was complete.

A non-probability, convenience sample of 30 volunteers was recruited. Thirty participants was the number determined to be needed to show statistical significance. Volunteers were screened to determine eligibility for the study. The four cohorts, totaling thirty eligible adults, were enrolled for a series of three appointments over a two-week period. Four participant inclusion and four participant exclusion criteria were established.

The inclusion criteria were:

- Participants had to be a minimum of 18 years old, healthy, and with no health complications.
- Each participant had to have a low caries risk assessment.
- Each participant had to have a minimum of three or more posterior teeth in each quadrant.
- Every participant had to agree to not brush or floss the posterior teeth, nor use mouthwash for the two-week trial period.

The exclusion criteria were:

- Participants could not have had any antibiotic use three months prior to the baseline data collection or during the trial period.
- Pregnant and/or lactating women were excluded from participating in order to protect the unborn and breast-feeding infants.
- Due to the possibility of staining, no more than two large posterior composite restorations were permitted per quadrant.
- Participants currently receiving orthodontic treatment were excluded because of the increased plaque retention that would skew the data.

A number, from one to thirty, was assigned to each volunteer at the baseline data collection session. Numbers were strictly assigned in a sequential order based on when each volunteer was able to arrive at the data collection session that corresponded to each cohort.

Data was collected three times, at one-week intervals: Baseline, week one and week two. Data collection included:

- Salivary samples were collected
- gingival Index (GIC) was determined
- Modified Quigley Hein Plaque Index (MQHPI) was determined after application of a disclosing agent
- Intra-oral photos of all posterior regions of the oral cavity were taken

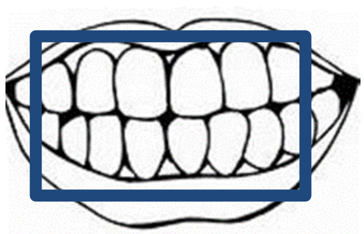
The gingival index measured the degree of gingival inflammation surrounding each of the posterior teeth of the study participants. Numbers, which are on a continuous scale, were assigned according to the criteria shown in Table I (*Tolle, 2010*). The MQHPI, also on a continuous scale, measures the amount of plaque that covers the tooth, as graphically represented in Figure 2 and described in Table II (*Marks, Magnusson, Taylor, Clouser, Maruniak, & Clark, 1993*).

The data collection proceeded in the following order. First, a salivary sample was collected from each participant by the principal investigator. All labeled and dated samples were immediately placed in a -20º C freezer, whose sole purpose was to store the samples. Then the gingival index was determined and recorded for each participant. The MQHPI was then determined by applying a plaque disclosing agent (GC Tri Plaque ID Gel®; GC Corporation, Tokyo, Japan) to the posterior teeth. After the recording of the MQHPI was complete, intra-oral photos were then taken for future reference. The gingival index and MQHPI were calculated by the PI. All data were entered into an Excel Spreadsheet.

Following baseline data collection, the PI instructed each individual to thoroughly brush and floss prior to application of either the treatment (silver nitrate) or control solution (saline solution). Each individual was visually checked by the PI to ensure that all of the disclosing agent, and thus the plaque, had been removed prior to application of the treatment (Silver Nitrate Solution 25%, Gordon Laboratories, Philadelphia, Pennsylvania, USA) or control (saline) solutions. The rationale of determining the baseline gingival index and MQHPI before application of the solutions was to determine each individual's "baseline status" at the beginning of the trial. Brushing and flossing after the baseline data was gathered was so that all participants would start with a clean slate in order to see changes, in whatever form, to the gingival inflammation and plaque accumulation.

Following the one-time application of either solution, 5% sodium fluoride varnish (Kolorz Clear Shield®; DMG America LLC, Englewood, New Jersey, USA) was immediately applied over the posterior teeth. These solutions and fluoride varnish were applied by an Oregon licensed general dentist, who was also blinded as to which solution the individual participants received. After application of the silver nitrate (treatment) or saline (control) solution and fluoride varnish, participants were instructed not to eat or drink for one hour. They were then instructed not to brush or floss the posterior teeth and not rinse with mouthwash for two weeks.

Participants could brush and floss the anterior teeth from the mesial of #6 (upper right canine) to the mesial of #11 (upper left canine), and from the mesial of #22 (lower left canine) to the mesial of #27 (lower right canine), using only a toothbrush moistened with water and no toothpaste. If a piece of food became trapped interproximally, participants were instructed to use floss at that site only. Tongue brushing was permitted with a toothbrush or tongue scraper moistened with water.



Anterior Teeth, #6-11, #22-27.

The salivary samples were used to determine the presence of salivary silver ions for all participants. There was the potential of silver ions originating from numerous sources, including industrial exposure, amalgam restorations, medicines/supplements, etcetera, as well as the silver nitrate for those in the treatment group. A baseline was necessary in order to determine if any silver ions were present prior to the silver nitrate application (treatment group only), and if so, whether or not the application of silver nitrate made an appreciable difference. Additionally, substantivity could then be determined. Therefore, three samples were required per participant: baseline, week one, and week two. Frozen samples were delivered to, and analyzed by, the Biochemistry and Molecular Biology Lab at the Oregon Health and Science University (OHSU) in Portland, Oregon. Any presence of silver ions could be detected in parts per billion via mass spectrometry. A repeated measure ANOVA (analysis of variance) was used for statistical analysis.

Results

Gingival inflammation

Table III highlights the results of the changes in gingival inflammation for both the control and treatment groups. The gingival inflammation of the control group progressed from the mild to moderate range over the course of the study. However, the gingival index of the treatment group did not exhibit a significant change. This group's gingival inflammation remained in the low-moderate inflammation range throughout the two-week study period. The gingival index scores were analyzed using repeated measure ANOVA. The increase in the gingival index of the control group (saline solution) was statistically significant ($p=0.03$) during the two-week duration of the study, while the gingival index of the treatment group was not statistically significant ($p=0.25$).

Plaque accumulation

Both groups experienced a significant increase in the amount of plaque accumulation, as represented in Table IV. From their respective baselines, the control group acquired slightly more plaque than the treatment group. For both groups, the greatest increase in plaque accretion occurred between baseline and week one (control $p = 0.0004$; treatment $p = 0.02$), but the overall plaque accumulation for the entire two-week period remained very significant (control $p = <0.0001$; treatment $p = <0.0007$). However, no significant difference in plaque accumulation existed between the control and treatment groups.

Salivary silver ions

The authors expected some level of silver to be detected in the samples due to the sensitivity of the mass spectrometer, which can identify ions in the parts per billions. Mass spectrometry of the salivary samples was performed twice to be certain of the results. Debris from the oral cavity that had been filtered out of the liquid portion of the saliva was also checked for silver. However, none of the salivary samples, liquid as well as filtered solids, analyzed via mass spectrometry revealed any detectable silver ions (data not shown).

Discussion

To the best of the authors' knowledge, this study had not been previously conducted. Under normal circumstances, with the cessation of oral homecare, one would expect gingival inflammation to increase while dental plaque also thickened and covered a greater surface area of the teeth, as was seen in the control group. The treatment group developed plaque in a similar fashion to the control, although to a slightly less, non-significant degree.

As the data revealed, the control group experienced a significant increase in gingival inflammation over the course of the two-week study period. However, the treatment group did not. Their gingival inflammation did not significantly change, in spite of an increase of plaque. This result leads one to consider the possibility that the virulence of the plaque differed between the two groups. Although the plaque scores were similar the extent and quantity of plaque does not reveal the bacterial composition within it. With that said, the bacterial species profile of the control group's dental plaque does not necessarily equate to the dental plaque sample of the treatment group. Perhaps the silver, from the silver nitrate, affected the difference.

Since no silver ions were detected in the salivary samples of week one (one week after the treatment group received an application of the medicament), it is unknown how long the silver ions remained in the oral cavity. It could have been minutes, hours, or days, but certainly not a week; otherwise the ions would have been detected by the mass spectrometry.

A clue as to the possible substantivity of the silver nitrate could be inferred from the remarks of two study participants, who, in retrospect, belonged to the treatment group. These two people independently stated at the second data collection session that for three or four days their teeth felt "squeaky" clean, in spite of a cessation of oral homecare on the posterior teeth. These statements suggest a possible substantivity of several days. However, the second data collection session was one week, not several days, after the placement of either the silver nitrate or saline solution, by which time no clinical difference in plaque accumulation could be readily observed.

There are several limitations to this study. The total number of participants, of which there were thirty, is small. In order to have a greater statistical power a larger cohort is necessary. Also, ideally, the study's duration should have been longer. Additionally, because the participants were not sequestered, the PI had to trust each of them to hold to the agreement that they would adhere to the requirements of the study. Every participant was asked at the data collection sessions of week one and week two if they had deliberately or accidently brushed and/or flossed their posterior teeth, used mouthwash or used toothpaste. All individuals stated that they had not, and that they had followed the verbal and written instruments they had been given. The objective data collected appeared to confirm these affirmations; however, the PI had no means to verify their compliance.

Conclusion

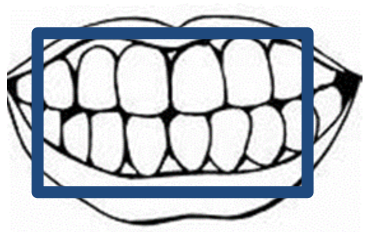
Silver ions have been shown to have a deleterious effect on bacteria. The question has been raised as to what effect, if any, silver ions have on oral bacteria, and specifically, what effect they have on the sequelae of gingivitis, periodontal disease, and dental plaque formation. This in vivo study attempted to investigate these questions, namely by assessing what effect silver nitrate have on the development of gingival inflammation and oral plaque accumulation, when compared to a control group. Thirty, healthy volunteers were divided into two groups, a control group that received a one-time application of saline solution, and a treatment group that received a one-time application of 25% silver nitrate, onto their posterior teeth.

Subsequent changes to their gingival health and plaque scores were assessed over a two-week period. Based on the results of repeated measure ANOVA, a 20 µL 25% silver nitrate application has the ability to prevent a worsening of gingival inflammation during a two-week cessation of oral hygiene, in spite of a significant worsening of plaque scores. Conversely, the control group had a significant increase in gingival inflammation, in addition to a significant increase in their plaque scores. Based on these findings, more studies are needed to determine the effect of silver nitrate on periodontal disease parameters, such as gingival inflammation, and on specific bacterial species. Future studies should be of longer duration, with more participants, with more frequent salivary samples taken and analyzed, and with various concentrations of silver nitrate.

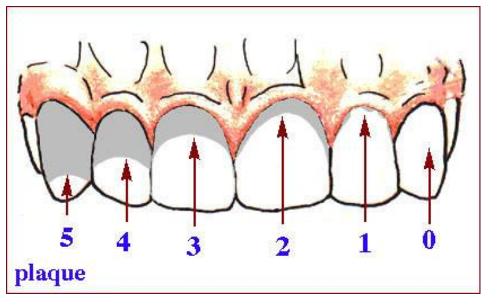
Editor's note (SD) Clearly this important contribution to the literature by Monika Alcorn represents an invitation for additional high-level investigations into the potential for silver ion compounds, in the treatment of gingivitis and other conditions of the periodontium and supporting structures of the teeth.

"Several groups are beginning to explore the possible effect of SDF enamel treatment on gingival health. Stay tuned as studies come out on this important subject." -S. Duffin

Figures



Anterior Teeth, #6-11, #22-27.



Modified Quigley Hein Plaque Index numeric representation.

Tables

Gingival Inflammation Index Numeric Values and Range

GIC #	Numeric Value
0	Absence of inflammation: normal gingival
1	Mild inflammation: slight change in color and slight edema
2	Moderate inflammation: redness, edema, and glazing, bleeding on probing
3	Severe inflammation: marked redness and edema, ulceration, tendency towards spontaneous bleeding
GIC range	**Condition**
<0.1	No inflammation (excellent)
0.1 to 1.0	Mild inflammation (good)
1.1 to 2.0	Moderate inflammation (fair)
2.1 to 3.0	Severe inflammation (poor)

MQHPI Categories

#	Numeric Descriptor
0	No plaque present.
1	Separate flecks of plaque at the cervical margin.
2	A thin, continuous band of plaque (up to 1 mm) at the cervical margin.
3	A band of plaque wider than 1 mm but covering less than one-third of the surface.
4	Plaque covering at least one-third but less than two-thirds of the surface.
5	Plaque covering more than two-thirds of the surface.

Summary of Changes of gingival Index

	N	Mean	Standard Deviation	p value
Control Baseline	15	0.98200000	0.48903988	n/a
Treatment Baseline	15	1.17000000	0.40194172	n/a
Control Week One	15	1.11600000	0.21326710	0.03*
Treatment Week One	15	1.25000000	0.22258225	0.31**
Control Week Two	15	1.26466667	0.17500476	0.03*
Treatment Week Two	15	1.27333333	0.24679855	0.25**

*significant increase in gingival inflammation (control group)

**no significant increase in gingival inflammation (treatment group)

Summary of Changes of MQHP Index

Data Session	N	Mean	Standard Deviation	p value
Control Baseline	15	2.01933333	0.53747381	n/a
Treatment Baseline	15	2.18133333	0.58456170	n/a
Control Week One	15	2.66333333	0.33506218	0.0004*
Treatment Week One	15	2.60133333	0.36556935	0.02*
Control Week Two	15	2.87533333	0.40172604	<0.0001*
Treatment Week Two	15	2.90200000	0.27477783	<0.0007*

*significant increases in plaque scores for both control and treatment groups

References

Addy, M. (1994). Local delivery of antimicrobial agents to the oral cavity. Advanced Drug Delivery Reviews, 13, 123-134.

Allaker, R. P. (2010). The use of nanoparticles to control oral biofilm formation. Journal of Dental Research, 89(11), 1175-1186. doi: 10.1177/0022034510377794

Armitage, G. C. (2010). Impact of periodontal infections on systemic health. In M. L. & M. M. Walsh (Eds.), Dental Hygiene: Theory and Practice (pp. 348-354). St. Louis, Missouri: Saunders Elsevier.

Clement, J. L. & Jarrett, P. S. (1994). Antibacterial silver. Metal Based Drugs, 1(5-6), 467-482. doi: 10.1155/MBD.1994.467

Demling, R. H. & DeSanti, L. (2001). Effects of silver on wound management. Wounds, 13(1 Suppl A), 1-15.

Donlan, R. M. & Costerton, J. W. (2002). Biofilms: Survival mechanisms of clinically relevant microorganisms, Clinical Microbiology Reviews, 15(2), 167-193. doi: 10.1128/CMR.15.2167-193.2002

Dorfer, C. E. (2003). Antimicrobials for the treatment of aggressive periodontitis. Oral Diseases, 9(Suppl. 1), 51-53.

Duffin, S. (2012). Back to the future: The medical management of caries introduction. Journal of the California Dental Association, 40(11), 852-858.

Espinosa-Cristobal, L. F., Martinez-Castanon, G. A., Martinez-Martinez, R. E., Loyola-Rodriguez, J. P., Patino-Marin, N., Reyes-Macias, J. F., & Ruiz, F. (2009). Antibacterial effect of silver nanoparticles against Streptococcus mutans. Materials Letters, 63, 2603-2606.

Feng, Q. L., Wu, J., Chen, G. Q., Cui, F. Z., Kim, T. N., & Kim, J. O. (2000). A mechanistic study of the antibacterial effect of silver ions on Escherichia coli and Staphylococcus aureus. Journal of Biomedical Materials Research, 52, 662-668.

Li, J., Helmerhorst, E. J., Leone, C. W., Troxler, R. F., Yaskell, T., Haffajee, A. D., ...Oppenheim, F. G. (2004). Identification of early microbial colonizers in human dental biofilm. Journal of Applied Microbiology, 97, 1311-1318. doi: 10.1111/j.1365-2672.2004.02420.x

Marks, R. G., Magnusson, I., Taylor, M., Clouser, B., Maruniak, J., & Clark, W. B. (1993). Evaluation of reliability and reproducibility of dental indices. Journal of Clinical Periodontology, 20, 54-58.

Marsh, P. D. & Bradshaw, D. J. (1997). Physiological approaches to the control of oral biofilms. Advances in Dental Research, 11(1), 176-185. doi: 10.1177/08959374970110010901

Marttila, E., Jarvensivu, A., Sorsa, T., Grenier, D., Richardson, M., Kari, K., ...Rautemaa, R. (2014). Intracellular localization of Treponema denticola chymotrypsin-like proteinase in chronic periodontitis. Journal of Oral Microbiology, 6, 24349. doi: 10.3402/jom.v6.24349

Matsumura, Y., Yoshikata, K., Kunisaki, S. –I., & Tsuchido, T. (2003). Mode of bactericidal action of silver zeolite and its comparison with that of silver nitrate. Applied and Environmental Microbiology, 69(7), 4278-4281. doi: 10.1128/AEM.69.7.4278-4281.2003

Mombelli, A. (2003). Periodontitis as an infectious disease: Specific features and their implications. Oral Diseases, 9(Suppl. 1), 6-10.

Nibali, L., Henderson, B., Sadiq, S. T., & Donos, N. (2014). Genetic dysbiosis: The role of microbial insults in chronic inflammatory diseases. Journal of Oral Microbiology, 6, 22962. doi: 10.3402/jom.v6.22962

Pal, S., Tak, Y. K., & Song, J. M. (2007). Does the antibacterial activity of silver nanoparticles depend on the shape of the nanoparticles? A study of the gram-negative bacterium Escherichia coli. Applied and Environmental Microbiology, 73(6), 1712-1720. doi: 10.1128/AEM.02218-06

Quirynen, M., Teughels, W., & van Steenberghe, D. (2003). Microbial shifts after subgingival debridement and formation of bacterial resistance when combined with local or systemic antimicrobials. Oral Diseases, 9(Suppl. 1), 30-37.

Rai, M., Yadav, A., & Gade, A. (2009). Silver nanoparticles as a new generation of antimicrobials. Biotechnology Advances, 27, 76-83. doi: 10.1016/j.biotechadv.2008.09.002

Richards, R. M. E. (1981). Antimicrobial action of silver nitrate. Microbios 31(124), 83-91.

Rosenblatt, A., Stamford, T. C. M., & Niederman, R. (2009). Silver diamine fluoride: A caries "silver-fluoride bullet". Journal of Dental Research, 88(2), 116-125.

Russell, A. D. & Hugo, W. B. (1994). Antimicrobial activity and action of silver. Progress in Medicinal Chemistry, 31, 351-370.

Silvestry-Rodriguez, N., Sicairos-Ruelas, E. E., Gerba, C. P., & Bright, K. R. (2007). Silver as a disinfectant. Reviews of Environmental Contamination & Toxicology, 191, 23-45.

Socransky, S. S. & Haffajee, A. D. (2002). Dental biofilms: Difficult therapeutic targets. Periodontology 2000, 28, 12-55.

Sondi, S. & Salopek-Sondi, B. (2004). Silver nanoparticles as antimicrobial agent: A case study on E. coli as a model for gram-negative bacteria. Journal of Colloid and Interface Science, 275, 177-182. doi: 10.1016/j.jcis.2004.02.012

Spacciapoli, P., Buxton, D., Rothstein, D., & Friden, P. (2001). Antimicrobial activity of silver nitrate against periodontal pathogens. Journal of Periodontal Research, 36, 108-113.

Tan, H. (2006). Prevention and arrest of root surface caries in Chinese elders living in residential homes (Doctoral thesis, University of Hong Kong). Retrieved from: http://hub.hku.hk/handle/10722/50947

Tan, H. P., Lo, E. C. M., Dyson, J. E., Luo, Y., & Corbet, E. F. (2010). A randomized trial on root caries prevention in elders. Journal of Dental Research, 89(10), 1086-1090.

Tolle, S. L. (2010). Periodontal and Risk Assessment. In M. L. & M. M. Walsh (Eds.), Dental Hygiene: Theory and Practice (pp. 305-347). St. Louis, Missouri: Saunders Elsevier.

Trombelli, L. & Tatakis, D. N. (2003). Periodontal diseases: Current and future indications for local antimicrobial therapy. Oral Diseases, 9(Suppl. 1), 11-15.

Venezia, E., & Shapira, L. (2003). Use of antimicrobial agents during supportive periodontal therapy. Oral Diseases, 9(Suppl. 1), 63-70.

Yilmaz, O. (2008). The chronicles of Porphyromonas gingivalis: The microbium, the human oral epithelium and their interplay. Microbiology, 154, 2897-2903. doi: 10.1099/mic.0.2008/021220-0

Caries Control Regimen – Risk Assessment & Treatment

(Dr. Martin L. MacIntyre, BA, DDS, MPH)

"I am delighted to introduce the reader to the life-work of Dr. Martin MacIntyre. He has been an inspiration to me and a full partner in the development of MMC and SMART Dentistry. This seminal work came from the experiences of a public health pioneer who saw the need for an alternative which addressed the failure of the traditional surgical approach to caries management. His three previously unpublished papers of caries management are included here to provide insight to the development of the Medical Management of Caries.

An illuminating interview with Dr. MacIntyre can be viewed at: https://youtu.be/ct8rA5TNz40 " -Dr. Steven Duffin

Background

The example of my parents' dedication to community service and my liberal arts undergraduate education have been the most important guides for my 55 years as a dentist and led me to a career in public health. I have been in clinical practice, instructional development, private preventive practice, and consulting. Having both experienced and provided dental treatment, I have always interest in prevention and avoiding the painful surgical approach to caries treatment.

My career has been in three major sections: 22 years as an officer in the U.S. Public Health Service, 13 years as the preventive dentistry coordinator for ARAMCO, the oil company in Saudi Arabia and 20 years in retirement discussing dental issues on the web via e-mail and at dental-public-health@list.pitt.edu.

I am a lifetime Diplomate of the American Board of Dental Public Health and received my master's in public health from the University of Michigan. I had a two-year National Health Service Corps clinical practice in low-income neighborhood and was a dental consultant to Head Start. I also reviewed the dental care programs in Guam and introduced sealants to the government program. For two years, I had a one-day a week private practice limited to prevention. I broke even (no-profit) due to low insurance fees, uncovered caries risk assessment and enormous paperwork.

I retired from the PHS and for the next 13 years was fortunate to be the preventive dentistry coordinator for ARAMCO. There were 200,000 beneficiaries with 160,000 being Saudi Arabian families and 40,000 ex-patriots. The caries rates ranged from caries-free American children to high risk Saudi Arabian children and the reverse for their parents.

I was awarded the Federation Dentaire International, Johnson & Johnson Preventive Dentistry Prize for the following programs at ARAMCO.

1) Resin sealant program;

2) O-TEAM, to prevent dental caries and periodontal disease while receiving orthodontic treatment

3) Caries risk assessment and control (**CRAC**)
   a) **SST** – Sugar Snack Test: simple, low-cost caries risk assessment test
   b) Comprehensive caries risk assessment and control guide

4) School Programs:
   a) Identify high-risk patients and teach the factors that lead to dental caries;
   b) Caries control treatment (**CCT**) uses glass ionomer cement as a combination sealant, fluoride reservoir and control of lesions;

5) Fluoride Programs:
   a) Check fluoride in company drinking water and adjust according to a formula.
   b) Fluoride urinalysis program to detect and correct toothpaste swallowing;

6) Safe and effective method to prevent caries in patients with low saliva secretion.

Three of these programs – CRAC, SST and CCT – are described in the following unpublished documents: The caries control treatment (CCT) is the major element because it can be used in large populations, without utilities or excavation by auxiliaries in less than five minutes a mouth.

These three documents have not been published before because they lack the data required by peer review journals, are too long for other journals and I had no association with an academic or research institution that might have published and distributed them. After thinking there was no hope to impart my knowledge and experience to a wider audience and seeing no significant change in dental practices, I was fortunate to find a varied group of like-minded dentists on the Internet. After a discussion of two to three years we eventually settled on the acronym SMART, to describe any method of painless prevention and treatment of dental caries using ionic silver and glass ionomer cement = Silver + Modified ART = SMART. In 2016, I prepared a major grant application to the MacArthur Foundation in the 100&Change competition based on SMART and auxiliaries. It made the first cut from 1900 applications down to 800. Dr. Duffin is doing this on his own and hopefully we will get a grant for a large scale (100,000 – 1,000,000) population of high-risk families to prove the major benefit of our approach.

Introduction and Rationale

Five (5) caries types are defined, with corollary treatment regimens that will arrest dental caries and prevent recurrence. Fourteen (14) procedures or agents are used. For TYPE I patients only four (4) are needed, of which two (2) are patient controlled (home care) and two (2) are clinician controlled (office procedures). On the chart, only new procedures are listed for the next highest caries type. For example, in TYPE II patients, only #s 5-7 are listed, but #s 1-7 are to be applied.

Maximum success requires individualized diagnosis and treatment. Other factors that might alter the regimen are listed to alert the clinician to these possibilities, but specific changes in the treatment plan are not provided. Alterations require a thorough understanding of:

1. The caries processes

2. The action and interaction of each agent or procedure

3. Most importantly - the patient.

Use the regimen unaltered and as you learn make adjustments based on your knowledge and experience.

Active, visible caries automatically places the patient into CARIES TYPE III or IV. However, a patient can be these types without visible signs of caries. The risk factors are obtained from objective assessment of a saliva specimen. The patient's caries type can be altered by clinical judgment using subjective factors which, although important, are difficult to verify or correlate, e.g. diet and oral hygiene. The Caries Control Regimen chart is a summary of the procedures, agents, treatment location, methods, conditions and recall periods. Risk factors, altering factors, and abbreviations are also included. The caries types are described in greater detail followed by a brief description of the fourteen (14) procedures and their application.

1. TYPE "O" patients have never had caries and have no risk factors. Many children and a few adults are TYPE O. Purists will say there is no such adult and that signs of demineralization can be found on the mesial of almost all permanent first mandibular molars. Therefore, TYPES 'O' and 'I' receive the same treatment.

2. TYPE "I" patients have not developed new caries or had progression of an existing lesion for the last 5 years AND have no more than one (1) risk factor. <u>Do not try to change their home care with respect to caries risk</u> until there is an increase in their caries risk. However, any <u>office</u> procedure that can reduce a risk factor should be used. The frequency of radiographs for caries detection can be reduced by monitoring risk factors with saliva tests.

3. TYPE "II" patients have not developed new caries or had progression of an existing lesion for the last 4 years OR they have two (2) risk factors. The treatment plan is directed toward high risk sites using antibacterial and remineralization treatments. If there is no salivary secretion risk, then flossing posterior contacts with chlorhexidine (CHX) and fluoride (F-) will be sufficient home care. It is assumed that the preventive measures over the last 4 years have been effective, but now is not the time to relax. The regimen maximizes preventive treatment at biannual office visits and a home program that maximizes the effect of minimum effort.

4. TYPE "III" patients have had visible, active caries within the last 3 years, OR have three (3) or more risk factors. It is important for the patient to be convinced that there is a major problem and that the problem will continue indefinitely, regardless of professional restorative or preventive treatments, unless he makes some positive behavioral changes. It is counterproductive to use the authoritative approach e.g., “if you don’t follow my recommendations you will end up with dentures”. The clinician's role is to convince the patient to change through the use of the diagnostic tests that graphically demonstrate the problem and that it is possible to

improve the test results with short-term office and home treatments. The recommended treatment plan will control caries risk factors. The Type III patient has a history of recurrent caries while under the care of a dentist, i.e. between scheduled exams. The cyclic pattern is frustrating for the patient and even more so for the clinician. This cycle can only be broken by a major caries control treatment and counseling effort. Everything that can be done in the operatory should be done, since it is under the clinician's direct control. It is important to initiate preventive treatment on the same day as the examination appointment. This demonstrates the seriousness of the problem, the potential for success is within the power of the patient. However, to depend on a change in the patient's behavior to achieve initial success is to guarantee failure. The last thing likely to be changed is the patient's behavior. At the same time, quick, demonstrable, positive results are a major factor in changing the patient's behavior.

5. TYPE "IV" patients have one or more risk factors that are extremely difficult, if not impossible, to eliminate or change. The most common factor is low or no saliva secretion as a result of non-dental disease or medication. Another example is orthodontic appliances. Dietary patterns related to medical conditions can increase caries risk, e.g. frequent small feedings by pregnant women to counteract nausea. Most cariogenic dietary habits are deep seated and are extremely difficult to change. These problems can be managed IF the patient and clinician (including the physician) are willing to make the effort. A patient is not able or willing to use one of the treatment modalities, e.g. CHX due to staining, but alternatives can be devised that separately are less effective, but in combination are equally effective. Most of these patients will need a regimen that they can continue on a daily basis for the rest of their lives.

CARIES CONTROL REGIMEN – Risk Assessment & Treatments

CARIES TYPE				PROCEDURE/ AGENT	SITE	METHODS	CONDITIONS	RECALL
IV	III	II	I	1 Saliva Tests & OHE	C	Specimen Cup	periodic examinations	1 - 3 years
				2 F-/AntiBtToothpaste	H	Floss/Brush	bid - am & hs	Exception:
				3 GIC	C	Sealant/F-	upon eruption $\rightarrow$ prn	Age 0-13
				4 Diet Control	H	Food/Drink	$\leq$5qd & 2+hr bet. & no snacks	6 - 12 months
				5 Sugarless Gum	H	Chewing	pc if no TMJ symptoms	6 months
				6 F- reservoir	H	GIC	risk sites	
				7 CHX gel/Rn	H	Rn/Floss/Brush	qid until $\downarrow$ rinse $\rightarrow$ floss hs	
				8 SN or SDF / FV	C	Application	prn for cavitations	
				9 GIC	C	SMART	Grade 3 or 4 caries	1 - 6 months
				10 Restorations	C	If Requested	1-3 mo after III-8	
				11 $CaCO_3$	H	Rinse/Brush	prn saliva pH <6.0	1 - 3 months
				12 Saliva-synthetic	H	Spray	after CaCO3 application	
				13 Sugar Substitute	H	Meals/Snacks	whenever feasible	
				14 Water	H	Drinking	qid bet. meals for SSR	

0 - Never had caries and no risk factors
I - No caries for the last 5 years AND no more than 1 risk factor
II - Active caries within the last 4 years OR 2 risk factors
III - Active caries within the last 3 years OR 3 or more risk factors
IV - Active caries in the last 3 years AND 3 or more risk factors OR irreversible risk factor
? **WHEN IN DOUBT, SELECT THE HIGHER CATEGORY**

OBJECTIVE SALIVA RISK FACTORS FOR DENTAL CARIES

1. **Sugar/chewing stimulated saliva secretion rate ml/min (SSR)**
2. **Buffering capacity (BC)**
3. **15 minutes sugar stimulated saliva acid level (ST)**
4. **Streptococcus mutans (SM) plus Lactobacilli (Lb) counts**

SUBJECTIVE FACTORS: **sugar intake; feeding frequency; oral hygiene**

FACTORS THAT MIGHT ALTER THE REGIMEN

1. **Carious lesions:**
   a. **symptoms**
   b. **number**
   c. **rate of caries progression**
   d. **proximity to pulp**
   e. **location (tooth & surface)**
   f. **physical characteristics**
2. **Enamel maturity (degree of mineralization)**
3. **DMFT/DMFS incidence and prevalence**
4. **Fluoride utilization history**
5. **Success of the previous treatment(s)**
6. **Medical conditions and medications**
7. **Age of patient**
8. **Patient cooperation**

ABBREVIATIONS

GIC	**glass ionomer cement**	F-	**fluoride**	ac	**before meals**	bid	**2 times daily**
Bis-GMA	**e.g. Delton, Helioseal**	C	**clinic**	pc	**after meals**	tid	**3 times daily**
CHX	**chlorhexidine**	H	**home**	hs	**before sleep**	qid	**4 times daily**
$CaCO_3$	**calcium carbonate**	qd	**daily**	w	**with**	$\geq \leq$	**or equal to**
SSR	**saliva secretion rate**	Bt	**bacteria**	→	**then**	>	**greater than**
SN	**Silver Nitrate**	Rn	**rinse**	↓	**reduced**	<	**less than**
SDF	**Silver Diamine Fluoride**	FV	**fluoride varnish**				

Procedures, Agents, Application Methods and Conditions

Caries risk assessment and oral health education

It is important for individuals to have an accurate knowledge of how caries develops and how it can be prevented, controlled and arrested over the long-term. Without this knowledge, it is highly unlikely that those with a caries risk level greater than ‘0’ will develop the daily habits necessary to avoid caries in the future. The knowledge won’t be accepted and used, unless the patient/parent is a willing partner and wants to succeed. Rather than providing unidirectional, authorization advice and instructions, it is necessary to do a motivational interview where the patient is encouraged to ask questions that will lead them to discover the information needed to achieve a risk level of ‘0’ by converting bad habits into good habits. To accomplish this there are a number of caries risk tests. In addition to educating and motivating the patient, they help identify specific caries risk factors and can monitor improvements or relapses.

A non-invasive caries-risk test battery can identify problems and changes in risk before they are detectable by x-ray or visual examination. This permits non-invasive treatment to be initiated before surgical treatment is required. While x-rays can identify lesions prior to irreversible damage, a minimum of 30% of the enamel mineral is lost before it can be seen on the highest quality radiograph. A few simple tests on a saliva specimen can identify a change in caries risk. The two simplest tests are buffering capacity and saliva secretion rate. These tests measure resistance. The cariogenic challenge is measured by bacterial culturing. A combination of resistance and challenge is measured by the Sugar Snack Test (SST). This test simulates a sucrose snack and measures the outcome of the resistance factors in the saliva vs. the challenge of the cariogenic bacteria. For TYPE I patients the test results can reduce the frequency of standard bitewing radiographs, confirm their low risk over time and monitor the effect of anticaries treatments. Patients can check themselves with a home SST self-test for biofeedback and to adjust the type and frequency of home care. Clinic time can be saved by having the patient report by phone or bring the results with them to their appointment. The frequency of re-testing depends upon the disease severity, the response to treatment and the patient's cooperation in self-testing. Obtain oral pH paper at these sites on the Internet.

There are commercial caries risk tests.

- http://www.naturallydirect.net/ph-paper.html
- http://www.healingdaily.com/conditions/salivaph-test.htm

- http://www.vaxa.com/913.cfm

F- toothpaste

Fluoride toothpastes are meant to be applied topically. World-wide the F- in toothpaste ranges from 250 to 1800 ppm. Almost all toothpastes in the U.S. are 1100 ppm. Fluoride toothpastes aid in the remineralization of enamel or dentin and add fluoride to immature tooth enamel in the form of fluor-apatite. Fluoride can also reduce the acid production by bacteria. The most recent research indicates that remineralization is the most important of the three modes of action.

Remineralization can only take place after demineralization. Therefore, F- must be present at the time the pH is lowered, e.g. during and after intake of fermentable material. Remineralization is most effective when the fluoride concentration is very low, e.g. 1 ppm as in drinking water. High levels of F- produce an intermediate calcium fluoride compound which is not stable and dissociates into calcium and fluoride in acid conditions. The fluoride is absorbed by the plaque, and to a lesser extent, the enamel, for use when and if the enamel is remineralizing. Higher concentrations are slightly more effective by extending the time of gradual F- release between brushings. Higher concentrations also are more likely to produce fluorosis if misused. Flossing brings the F- toothpaste to the sites of highest risk. The toothpaste also helps the floss pass through the proximal contact.

Brushing and flossing <u>before</u> eating has greater rationale for caries control than after eating and could be suggested to the highly motivated high-risk patient. However, people who floss usually do it to remove food particles and to prevent mouth odor. Brushing is the primary way to get fluoride into the mouth and can be effective in preventing gingivitis. Many people use toothpicks to remove food particles immediately after eating. For caries control, reduction in the amount of cariogenic bacteria and increasing the F- content of the plaque before eating is biologically sound, since we want to reduce the bacteria available for acid production and we want F- to be present when acid is produced. However, this practice is unlikely to find widespread use. Oral hygiene before eating could be connected with other hygiene measures such as hand washing. Although widely known, the recommendation to brush after meals is not followed because it is seen as impractical. In summary, brushing and flossing before eating might have some benefit but is not likely to be used and requiring these practices after eating is not likely to be performed and will have less effect. Thorough oral hygiene once a day is the best we can hope to accomplish.

Sealant

All pits and fissures should be sealed within 3 months after eruption. It is impossible to know with assurance which teeth are safe from caries. However, we know that if a patient were to develop caries, the first site is likely to be in pits and fissures. The Bis-GMA (e.g. Helioseal, Delton etc.) type of resin sealant material has the best history for longevity and has been shown to be of equal effectiveness with glass ionomer cement sealants. However, application requires a fully erupted tooth in a very dry field. It can take as long as a year or more for all four first or second molars to erupt and, even then the buccal pit of the lower first molar, or the lingual groove of the maxillary molars, not be exposed enough to permit adequate sealing with a Bis-GMA material. A second problem is the incomplete mineralization of the enamel of the newly erupted immature tooth. The question is still open as to what will happen ten years after a sealant application if the sealant is worn away and the "original", partially mineralized, fissure enamel is exposed. Will the tooth have the high-risk level of a newly erupted tooth? It is already known that there is an increased risk of caries if a Bis-GMA sealant isn't completely sealed (leaks) due to insufficient etching or rinsing.

To avoid these problems or potential problems, it is recommended that all patients receive a glass ionomer cement sealant, e.g. Ketac-Fil, Fuji-Fil, at their examination appointment for all unsealed molars including those that are partially erupted. The exception would be fully erupted permanent molars in TYPE I patients who can have either GIC or Bis-GMA applied at a regular appointment. Glass ionomer cement (GIC) can be successfully placed where complete isolation is not feasible. The fluoride it contains can aid development of fluor-apatite in the pits and fissures, as well as adjoining tooth surfaces. The fluoride concentration is low and constantly available which is ideal for mineralization/remineralization. In a 3-year-old patient with no other source of fluoride and all eight primary molars sealed with GIC, the urine fluoride level two weeks later was 0.50 ppm, meaning the fluoride level was within normal limits and wouldn't cause fluorosis. In an adult patient, with no other source of fluoride and over 20 teeth with large GIC temporary restorations, the urine fluoride level was 1.0 ppm. This treatment provides a highly desirable topical fluoride level always available at a safe systemic level of fluoride, if monitored properly.

GIC is so easy to apply in a short time period that it can be accomplished by either the dentist or dental therapist without rescheduling the patient. For erupting third molars, GIC sealant/F- reservoir should be placed regardless of the previous caries activity or risk. GIC can be used in less than ideal situations because, unlike Bis-GMA, the initial setting reaction is hydrophilic and, therefore, less sensitive to moist oral conditions. The bonding mechanism is electrochemical and is a one-step procedure, i.e. etching is contra-indicated. Reduced isolation requirements make it possible to work in multiple quadrants. Clinical use is further eased by using the finger for application and adaptation. When the tooth reaches the occlusal plane, the GIC sealant might need adjustment to allow proper occlusion, or it might be partially or completely lost due to the occlusal forces.

GIC does not withstand occlusal forces as well as Bis-GMA. It does not "wear down" like Bis-GMA, is more likely to "fracture" under stress conditions and is less likely to be maintained in a thin layer. Occlusal adjustment might make the GIC sealant too thin to withstand occlusal forces. Only a small amount is required to have an anti-cariogenic effect. When all the molars have erupted and are in stable position, the status of the GIC sealants should be reassessed and, if necessary, refurbished or replaced with Bis-GMA sealant. Bis-GMA sealants that release fluoride have been developed for orthodontic and general use e.g., Helioseal F. However, when compared with GIC, the amount of fluoride release is generally less and doesn't last as long. On the other hand, the visible retention of GIC is very low when compared to Bis-GMA. The bottom line, caries protection has been equal.

If the patient has never had caries and is over age 25, then the need for sealants is debatable except for mothers of newborns in order to reduce sites for S. mutans. The risk of developing pit and fissure caries in a tooth that has been caries-free for 10 or more years is very low. However, if their lifestyle were to change, e.g. diet, or there was an increased level of inoculation (intimate contact with someone highly infected with SM), then caries could develop where it had previously been absent. A few cases like this have been documented in adults. Sealing teeth not only drastically reduces the risk of caries in the sealed tooth, but also reduces the risk of caries in unsealed teeth by preventing biofilm imbalances and bacterial transfer.

There are pros and cons on using a transparent or an opaque Bis-GMA sealant. If it is transparent it can allow the clinician to see if there is any caries developing underneath or if it is leaking. But, it also encourage dentists who are not convinced of the value of sealants to remove them and replace them with amalgams.

Diet control

These are simple dietary rules that will reduce caries risk and promote a healthy nutrition:

Eat Only at the Eating Place - When hungry, prepare good food and sit down at the table to eat, e.g. kitchen or dining areas. Eat enough to prevent hunger for at least three hours.

Balanced Meals - Foods that take a long time to digest delay the mechanism for triggering hunger.

Raw and unrefined foods, proteins and fat take longer to digest. Snack foods usually contain refined carbohydrates which are easily metabolized by oral bacteria and do not satisfy hunger for very long. A combination of foods is more likely to keep the refined carbohydrates away from the dental plaque. A balanced meal delays hunger and also removes hunger as a reason for snacking.

Maximum of Five Meals with No Snacks - Saliva cannot neutralize or remove the bacterial acids sufficiently if acid is produced more than five times a day.

Three Hours Between Meals - It takes three hours for saliva to remove the acid made by the bacteria and then replace the lost tooth minerals. Eating too soon means some of the lost mineral will not be replaced.

Television and Eating Do Not Mix - Eating while watching TV lengthens the bacteria's feeding time and the time for bacteria to make acid. It also shortens the time between feedings.

Floss with Fluoride Every Day - Flossing fluoride toothpaste between posterior contacts aids remineralization.

Sugarless gum

Chewing sugarless gum is a newly recommended habit to follow eating, especially for children. It is sweet, leaves a fresh taste in the mouth, reduces the level of acid, is already an accepted activity for most patients and is considered a treat. It can be placed at the table for easy access, like toothpicks, and does not require any extra effort. Gum chewing should not be recommended for patients who might aggravate their TMJ. Chewing gum containing only sorbitol as a sweetener should be avoided if alternatives are available. So check the label. Xylitol gums are preferred because they are actually anticariogenic and in some studies a 70% reduction in cavities (dmft). Research also suggests that xylitol attracts and then "starves" cariogenic bacteria allowing remineralization with less interruption.

Having stated the positive caries control aspects of chewing gum it must be said that it is unattractive and interferes with speech. Consul the patient about when chewing gum is a health aid such as just after eating and as a substitute for compulsive eating or to aid in smoking cessation vs. social situations (conversation).

Fluoride reservoir

A fluoride reservoir is any fluoride-releasing material placed at a specific caries risk site to increase the remineralization potential. Low levels of fluoride ($\leq$1 ppm) are the most effective aids to remineralization. They are only effective when demineralization is taking place. The presence of fluoride in dentifrice, gum, food and water is an excellent way to provide topical fluoride, but it is not present when demineralization is taking place. A sealant, restoration or other site-specific addition of a material that slowly releases fluoride is ideal for remineralization. Glass ionomers have been shown to have this quality and new hybrid sealants are available for this purpose. There is also fluoride varnish.

Anti-bacterial agents

Chlorhexidine:

For persons with two (2) or more risk factors and a recent history of active caries there are likely to be undetected sites of active demineralization. These should be treated by remineralization and reduction in the quantity of pathogenic bacteria. This can be accomplished with F- and CHX separately as well as in combination over a limited period of time. F-products usually contain one or more elements (phosphate, sodium lauryl sulfate or low pH) that in some in vitro tests have appeared to reduce CHX effectiveness. However, in vivo and in vitro tests performed by the author have only shown differences that are not clinically significant. For application, a rinse is the first choice because it is more likely to reach the high-risk site below the approximal contacts, does not require a tray and has higher patient acceptance. One month of multiple daily applications including use with floss, will greatly reduce the bacterial counts and permit remineralization to proceed. Any stain can be removed at the one-month monitoring visit when the maintenance regimen is instituted. Flossing posterior contacts with CHX/Neutral NaF saturated floss is used to maintain the low bacterial count in the high-risk area. The bacteria that are likely to remain after flossing are the most pathogenic ones and are in the gingival sulcus, or firmly attached to the enamel pellicle. Antibacterial agents applied with floss are used to control these remaining bacteria. A study has shown that, if these bacteria are not controlled and the patient continues to have a high sucrose diet, caries will continue and possibly accelerate AFTER flossing. Since diet control is difficult to maintain for long periods, it is important to have an effective supporting method, in this case, bacterial control.

For TYPE III patients a 3-month course of CHX is recommended. It is desirable to have the patient under the CHX coverage while operative treatment is completed (both temporary treatment restorations and definitive restorations). This will permit the necessary radical change in their oral biofilm (from cariogenic to non-cariogenic) and allow time for the patient to make a radical change in their oral habits' vis a vis diet and oral hygiene. If they can demonstrate to themselves and to you that they can go three months in a healthy state (low risk levels including plaque reduction) then there is reason to think that a long-term change is possible. The diet and flossing habits will be the most difficult to establish in TYPE III patients and it might take as long as a year or more. Flossing is essential for successful control.

In the United States, CHX comes as a rinse (Peridex®) and varnish (Cervitec + ®). The concentrations of the rinse and gel are approximately equal when considering the amount of active ingredient in a single dose. The gel has about five times the active ingredient in equivalent amount by weight. The bottle of mouthwash contains six times the amount by weight (300 gms) as the tube of gel (50 gm). In practical terms, one 2 cm strip of gel has the same amount of CHX as 10 ml of mouthwash. CHX varnish has been perfected and tested with extremely positive results. It has been shown to suppress S. mutans for 3-12 months. This would reduce dosage and frequency of application, increase the effectiveness and avoid the staining (These statements on CHX varnish need to be updated).

Povidone-Iodine

Povidone-Iodine is an antiseptic to the teeth and mucosa especially in children at high risk for caries. It can be applied and then followed with fluoride varnish. Contraindications are iodine sensitivity, a history of thyroid disease, and pregnancy.

Silver Nitrate (Sn) and Silver Diamine Fluoride (SDF) (Also See #14)

The silver in these compounds is the antibacterial element. They are applied as liquids overactive caries and then covered with fluoride varnish or glass ionomer cement (GIC). SDF or SN + GIC = SMART (Silver + Modified ART – Atraumatic Restorative Treatment).

Interim Therapeutic Restorations (ITR) for caries control (pre-emergency)

Atraumatic Restorative Treatment (ART) for Caries

Open cavitations or Grade 4 lesions (more than ½ way through the dentin) should be considered for a glass ionomer ITR. Soft debris should be completely removed. The pulp has been under attack by bacterial acids and toxins and should be spared the additional insult of traumatic operative cutting procedures, even hand instrumentation. If the lesion is large enough, calcium preparations, e.g. DYCAL, can be placed over the area nearest the pulp to neutralize the acid. This is followed by glass ionomer cement to provide fluoride, to avoid thermal conduction and to seal the cavity from bacteria. More teeth can be treated at a single appointment than with the standard temporary treatment methods because no anesthetic is used, there is minimal or no caries removal, no cavity preparation. Placement of GIC is simple and fast. This approach is biologically sound and provides the patient with maximum caries control.

Do not return the tooth anatomy to the "correct" form and function. The purpose is to protect the pulp from further insult so that it can repair itself. Keep the marginal ridge out of occlusion to reduce the chance of fracturing the glass ionomer cement. Do not use a matrix band because the placement be painful; initiate bleeding; takes time; the matrix removal could fracture the GIC; and it will prevent additional retention via GIC bonding with the adjacent tooth. Contact of GIC with the interproximal gingiva does not produce inflammation.

Atraumatic Restorative Treatment (ART) is similar to ITR and has been used for over three decades in public health settings. ART attempts to remove most decalcified dentin and restore form and function as a final treatment. SDF or SN + GIC = SMART (Silver + Modified ART – Atraumatic Restorative Treatment).

Definitive restorations

Once caries control treatment has been completed, it is desirable to wait for 1 - 3 months before placing definitive restorations. This allows the pulp to recover from the chronic caries attack. It also reduces the chance of placing a definitive restoration in a tooth that has an irreversible pulpitis. After the risk factors are reduced and the pulp has had a rest, then replace the temporary restoration with a definitive one. At this point there will be some hope that the word "permanent" will have some meaning. Permanent will still be a misnomer unless the causes of the caries have been removed to the point of avoiding recurrent caries. For primary teeth, there is no need to remove any additional tooth structure until the teeth exfoliate.

Antacid - Calcium Carbonate ($CaCO_3$)

An antacid can counteract chronic oral acidity that has been resistant to the previous methods. Almost any antacid will reduce the acidity temporarily, but many of the common brands contain sugar as a sweetener. Most of the antacids contain magnesium which, if ingested in large amounts, will have a negative effect on systemic calcium retention. They also contain aluminum which, for a while, was linked with Alzheimer's disease. For that reason, it is best to prescribe a CaCO3 suspension that is prepared by a pharmacist. The suspension is usually made with glycerin. The patient can rinse with it whenever the saliva pH is < 6.0. They can check the acidity with Oral pH paper that is available from a pharmacy or try the following that I found on the Internet.

- http://www.naturallydirect.net/ph-paper.html
- http://www.healingdaily.com/conditions/saliva-ph-test.htm
- http://www.vaxa.com/913.cfm

One drawback of this agent is the dry feeling it produces in a mouth that is already dry. On the other hand, the dry mouth retains the CaCO3 for a long time. This single method has maintained an adult patient with Sjogrens syndrome in a caries-free state for 8 years after having received 56 restorations in the previous 5 years of treatment (12 of them replaced once or twice during that period).

Renew 2 x

- Rx: Calcium Carbonate 50% Susp. In glycerin with pink color. 300 ml.
- Disp: 1 bottle
- Sig: Rinse p.c., h.s., and p.r.n. oral pH <6.

Synthetic saliva

Synthetic saliva is designed for a patient with a dry mouth. It permits food to be chewed and keeps lips from sticking together. It usually contains one ppm of fluoride to help remineralization. It is especially useful as a coating following a CaCO3 rinse.

- Rx: Xerolube (or other brands)
- Disp: 2 bottles
- Sig: Following CaCO3 rinse to reduce dry feeling.

Sugar substitutes

There are many sugar substitutes on the market with a variety of trade names. They work by keeping the patient from using sugar, by stimulating saliva and, in the case of xylitol, by reducing the acid produced by acidogenic bacteria. Xylitol is the most effective because it is anticariogenic. It is also the most expensive because it is a natural product that is harvested from trees. Xylitol has been successfully incorporated into chewing gum and shown to reduce caries rates and activity in children. Xylitol is the sole sweetener in XYLIFRESH, made in the U.S.A. Xylitol is combined with sorbitol, another sugar substitute, in TRIDENT chewing gum manufactured in Europe while TRIDENT made in the U.S.A. has only sorbitol. Aspartame is a protein that is marketed as NUTRASWEET or CANDERYL or EQUAL and is used in soft drinks and in crystalline form as a substitute for table sugar and in chewing gum. Aspartame loses its sweetness at higher temperatures and cannot be used in most products that are cooked (baked goods) or hot drinks (coffee). All sugar substitutes have some drawbacks, so you should be knowledgeable about the product before recommending it. Fructose is also available in the markets for use as a sucrose substitute. There is a slight advantage to using fructose vs. sucrose, since it provides S. <u>mutans</u> with less of the energy it needs to "stick" to the smooth surfaces. Also, per serving, fructose is sweeter than sucrose. However, fructose is <u>not</u> a sugar substitute and produces the same amount of calories and bacterial acid per gram. One of the more recent sweeteners that is very low in calories is Stevia from the leaves of a plant called Stevia rebaudiana. It is gaining popularity, but I know of no studies vis a vis dental caries.

Water

Increasing the amount of water intake will increase the amount of saliva, as well as urine. Fluoridated water is best. The caffeine in soft drinks and coffee and similar agents in tea are diuretics and dry the mouth. Sugar pulls water into the intestinal tract which increases thirst. This is why soft drinks don't quench thirst.

Anti-bacterial agents

Antibacterial agents against caries have been used since the 1880s. The most prominent has been silver nitrate. It was used by W. D. Miller and G. V. Black and then by Percy Howe at Forsyth Dental Infirmary. It stopped being used with the discovery of the effect of fluoride and the use of local anesthetics that allowed for painless removal of tooth structure. However, fluoride is only antibacterial at very high concentrations and is only retained for a short time, from minutes to a week at most. In the 1970s another antibacterial chemical compound was developed and used by Craig in Australia which combined silver and fluoride into one compound, as silver diamine fluoride. It has been well studied in Australia and Asia but not in the United States because it has only just been approved for use by the FDA in 2015 and then only for tooth sensitivity. It can be used for the treatment of caries, but it is off-label. Silver nitrate as a 50% aqueous solution has been available continuously since the 1880s. Both forms kill the bacteria and hardens the decay with the only negative side effect being that the silver oxidizes and turns the caries black. If necessary, the stain may be mitigated by application of potassium iodide (KI). Some have questioned the use of KI because it reduces the effect of SN and SDF. Both SN and SDF have a bad taste which can be counteracted by covering with fluoride varnish or GIC.

Prophylaxis

Thorough daily cleaning of the tooth enamel surface has been shown to be effective in preventing caries. Per Axelsson's studies in Sweden are the modern references. The key is <u>thorough</u>, <u>daily</u> cleaning of the <u>susceptible tooth surfaces</u>. While the tooth cleaning efforts by children, adults, or parents meet the daily test, they don't meet the thorough or susceptible tooth surface tests. Rarely does the cleaning reach the sites must susceptible to caries, i.e., not at all in the pits and fissures and only with flossing for interproximal surfaces. Finally, in the population that develops ECC (early childhood caries), it is unlikely that they will thoroughly clean the primary incisors and they are likely to indulge in frequent feeding of their child because food is a great babysitter. It is for these reasons that prophylaxis isn't included as a treatment for caries even though "a clean tooth never decays." That said, toothbrushing is a great way to apply fluoride to the oral environment (see #2.)

A Caries Control Treatment Using Glass-Ionomer Cement

(Dr. Martin L. MacIntyre, BA, DDS, MPH)

Summary

A glass ionomer cement fluoride-sealant caries-control treatment (CCT) has been developed for the prevention and control of dental caries. The primary use is in field locations for high-risk, under-served patients. With a double-gloved finger, type 2 glass-ionomer cement is applied to open carious lesions as a caries control treatment and to sound pits and fissures as a combination fluoride reservoir/sealant preventive procedure. CCT is simple, safe, painless, effective and low-cost. Auxiliaries, under a dentist's supervision, can perform it as safely and efficiently as a dentist. The entire posterior dentition can be completed in three minutes. This procedure is controversial among dentists but is well received by patients and parents. It has not been tested in controlled studies but was used for 10 years without incident on over 150,000 teeth.

Introduction

Caries prevalence and incidence have decreased significantly in some populations, but others are experiencing a caries epidemic (*Marthaler, 1983*) (*Allukian, 1993*) (*Smith & Lang, 1993*) (*Flanders, 1988*). For high-risk children, comprehensive care is rare, caries recurrence is common and tooth extraction is relatively routine. They need an interim treatment to prevent pain and tooth loss until the primary teeth exfoliate and for their permanent dentition, they need to delay caries progression until definitive treatment can be obtained. In addition to being effective, a sustainable caries control treatment must be simple, fast, low-cost and painless.

CCT Procedure

General description

Caries Control Treatment (CCT) is the placement of glass ionomer cement (GIC) over pits and fissures and into open, asymptomatic carious lesions.

Indications and contraindications

CCT is used whenever conventional treatment is not feasible and the patient will not be harmed by the treatment. After the patient and parents are questioned about any history of painful teeth, visual screening identifies all teeth for which CCT is contraindicated (**Table 1**; refer to page 311).

Materials

Table 2 (refer to page 311) lists the easily obtained equipment and supplies. All items that contact the patient are disposable.

For CCT, the desirable properties of GIC are listed in **Table 3** (refer to page 311) (*McLean & Wilson, 1974*) (*Mount, 1984*) (*Leinfelder, 1993*). Chemical bonding of GIC to enamel, dentin and partially demineralized dentin reduces marginal leakage. A hydrophilic setting reaction provides a leeway in moisture control. Fluoride release aids remineralization and reduces the production of bacterial acid.

Method

Table 4 (refer to page 312) lists the main steps in the CCT procedure. The clinician performs all steps, unless otherwise indicated. The following is a detailed description of each step.

Step 1. From a tube, the assistant squeezes petrolatum onto the back of the clinician's newly-gloved hand, which will prevent cross-contamination. The clinician then lightly coats his/her fingertip(s) with petrolatum, which will keep the GIC from sticking to the glove.

Step 2. Use a toothbrush (without toothpaste) to remove gross debris and plaque from the occlusal surfaces and all cavitation's. As an option, you place polyacrylic acid on the brush to encourage the development of an anti-cariogenic fused layer between the GIC and tooth structure.

Step 3. Place gauze, or a cotton roll, between the patient's posterior teeth and have him/her close. This will reduce moisture on the occlusal surfaces. Drying with compressed air is undesirable because the GIC bonding and setting reactions are hydrophilic. CCT is contra-indicated in the presence of debris, swollen gingiva or blood because they are not displaced by GIC. Plaque, pellicle and biofilm reduce bonding but do not prevent the action of fluoride released from GIC.

Step 4. An assistant mixes the GIC with a triturator and then ejects a small amount from the disposable capsule onto the clinician's fingertip(s). Only the end of the disposable capsule touches the finger. Neither the assistant nor the GIC applicator (re-useable) touches the clinician or the patient.

Step 5. With firm finger pressure, place small amounts of GIC on the occlusal pits and fissures of intact teeth. Small amounts and firm pressure minimizes the thickness of the sealant to avoid occlusal interference in an area of the tooth where there is normally little, if any, inter-arch tooth contact. If placed according to these instructions, there is almost no chance of having occlusal interference when GIC is placed on intact occlusal surfaces or in cavitation's.

GIC forms a chemical bond upon contacting relatively clean tooth surfaces, including partially demineralized tooth structure (decay/caries). Excess GIC on the occlusal must be meticulously avoided because after three minutes it becomes increasingly difficult to remove with hand instruments and after 15 minutes rotary instruments are required. The final set and bonding process between GIC and the tooth structure continues to mature and strengthen for days.

Step 6. Apply a light coat of petrolatum over the GIC to protect it from oral fluids and to prevent any possibility of inter-arch adhesion of GIC (bonding jaws together).

Step 7. Without directing the patient, hold the chin and firmly tap the arches together in centric occlusion until you feel and hear enamel-to-enamel contact (*Feigal, Hitt, & Splieth, 1993*). Although GIC products differ among manufacturers, in general, GIC is malleable for only three minutes after mixing starts. The tapping displaces any minor occlusal excess and avoids the need to remove interferences after the GIC has set. Because there is no anesthesia, patients can tell immediately if their "bite" isn't normal. If Step 5 has been performed properly, the "bite" should feel normal to the patient. However, if there is an occlusal interference, then immediately use articulating paper and a sharp hand instrument (carver or excavator) to remove the excess. This is easy to do within the three to five-minute period. The most likely teeth to have interference are those most posterior and those without steep cusps. Remember, after the first five minutes hardening proceeds rapidly.

Step 8. Place a folded-gauze under the tongue and out between the anterior teeth. This keeps the dental arches apart, allowing initial set to proceed undisturbed. The gauze also absorbs saliva from the submaxillary and sublingual glands that might contaminate and dissolve the surface GIC. Finally, it allows the patient to be dismissed from the chair (but not from the treatment area) so the next patient can be immediately seated. The dismissed patient waits for two minutes before throwing the gauze into the infection control waste container. This is the last chance before being dismissed to ask that patient about occlusal interference. "Do your teeth close normally?" By their speaking you confirm they can open their mouth and there is no inter-arch adhesion. While inter-arch adhesion would seem to be an impossibility due to the many step that are designed to prevent it, it happened once when an operator, 1) applied far too much GIC, 2) didn't apply the petrolatum, 3) didn't check the occlusion 4) didn't place gauze between the anterior teeth and 5) didn't ask the patient a post-treatment question. This series of five consecutive human errors proves that Murphy's Law exists and that even trained professionals can fail to follow simple procedures or consider their responsibility for the patient's safety.

Step 9. The clinician performs hand washing while the assistant seats the next patient. Because the assistant has no contact with the clinician or the patient, the assistant doesn't need to wash hands between each patient and the GIC applicator can be reused. For the clinician, double gloving with antiseptic wiping of the under-glove is an alternative to hand washing between each patient. Proper decontamination of the skin via hand washing takes three minutes, which is as long as it takes to perform the procedure. Human skin can only withstand a certain number of correct hand washings over a continuous period and therefore hand washing frequency, three minutes per patient, and muscle fatigue are the limiting factors on how many patients can be treated by one clinician in one day. Double gloving between patients more than doubles productivity (cost per patient) and saves the skin of the operator.

Manufacturer's instructions

The manufacturer's instructions for Type 2 glass ionomer cement are based on its intended use as a restorative material. However, CCT is a preventive procedure and has less stringent requirements e.g., retention for months instead of years.

For CCT, the tooth surface is not as clean or dry, as recommended, and pre-treatment with polyacrylic acid (tooth conditioner) is not normally used, because of the time factor and the unpleasant taste for young patients. It might be possible to put tooth conditioner on the brush to increase the potential for the development of a fused interface (true chemical bond) between GIC and tooth structure. It might also be possible to treat the carious surface with an antibacterial agent like silver nitrate or silver diamine fluoride. Without a study, it cannot be known what the effect of a cleaner or dryer surface or the antibacterial agent would have on retention, or more importantly, the treatment goals. Based on clinical experience, the GIC remains long enough to produce remineralization. There have been instances where only a small speck of GIC has remained in the base of a large cavity, but the caries remineralized and was hard to an explorer point. Whether cleaning the cavities and tooth surfaces with tooth conditioner warrants the need for additional instruments and time, would require a controlled study. Even if plaque, pellicle and biofilm totally prevented bonding of GIC with the tooth structure, the GIC will conform to the cavity surface to provide an intimate and continuing source of fluoride as long as it is retained. Any leakage will not exacerbate the caries process, because fluoride is in contact with the surface and fluoride is a bacterial toxin as well as a remineralizing agent.

Unlike a restorative procedure, CCT is not an “all or nothing” procedure. If some of the GIC is not retained, the remainder is still a source of fluoride and does not increase the risk of exacerbating caries, which is a factor in a fractured restoration or a partially sealed Bis-GMA sealant. The procedure can be performed in only 3 minutes by trained non-dentists at a relatively low cost, which means it is preferable to repeat the procedure on a frequent cycle, e.g. every six months, rather than spend a significant amount of treatment time for a resin sealant in order to produce a small increase in retention and perhaps no increase in effectiveness.

The manufacturer provides a varnish to protect the GIC surface immediately after placement. The varnish has a strong odor that is unpleasant to children and it requires sterile or multiple disposable applicators. Odorless and inexpensive petrolatum is an adequate varnish substitute for initial protection against GIC dissolution in oral fluids (*Seeholzer & Dasch, 1988*) (*Indian Health Service, 2010*) (*Saleh & Khalil, 1994*) (*McKnight-Hanes & Whitford, 1992*). Although the petrolatum contaminates the outer surface of GIC, it doesn’t affect the bond between the GIC and the tooth structure. Petrolatum also masks the slight acidic taste of GIC.

Facilities and equipment

CCT can be performed almost anywhere. Natural or artificial lighting is adequate, and water is only needed for hand washing. Compressed air and suction are unnecessary and even undesirable. Patients can sit, stand, kneel or lie on their backs to be treated. Although GIC can be hand-mixed, a capsule system with a mechanical mixer significantly improves cost-effectiveness by quickly and consistently producing high-quality mixes. It saves time, reduces the number of instruments, and eliminates the need for sterilization equipment. A standardized mix is very important. A hand mix can take one minute, thereby reducing treatment time, the freshness of the mix, and the thickness of the mix – all crucial factors in achieving consistent results, avoiding occlusal excess and maximizing application time before GIC set. If electric current is unavailable, unreliable or too expensive, then a mixer can be made that is powered by a coiled spring or batteries or a mechanical vibrator powered by bicycle spokes. There are resin-modified glass ionomer materials that mix the material in the delivery instrument. This would eliminate the need for a triturator and electricity, but the mix has less body making application with a finger more difficult and it releases less fluoride. The only proven product is pure GIC.

Instruments

There are many advantages to using a finger as the primary, and usually the only, intra-oral instrument for CCT. The finger provides direct, safe, non-threatening, sensitive and versatile application of GIC. Graduated pressure over the entire occlusal surface cannot be achieved any other way. Fingers are also used to retract the tongue and to apply the petrolatum. This saves time, money and materials with increased effectiveness.

Personnel

CCT requires two individuals who perform five distinct functions. A dental hygienist, dental therapist or dentist would normally apply GIC, but responsible individuals with normal dexterity and intelligence who have an above average sense of responsibility can learn to perform CCT with minimal training. The assistant is essential for infection control, cost-effectiveness and patient management. Because CCT can be performed in approximately three minutes, as many as 15 patients can be treated in less than one hour. It is useful for the assistant and the clinician to exchange roles to prevent muscle and mental fatigue.

The first function is diagnosis -- <u>to determine which teeth **should not** be treated</u>. This is the only function that must be performed by a dentist or specially trained dental therapist. The second function is placement of GIC – quickly and without occlusal interference. The third function is patient management and teamwork between the clinician and assistant. Patients can be as young as 16 months and the treatment room can be crowded and noisy with other children watching and waiting their turn. The fourth function is assisting and infection control. The fifth function is collecting and recording the patient information. It is highly desirable to have a third person perform this last function to maintain consistency in data collection and, to manage the patients before and after treatment – allowing the clinician and assistant to focus on the patient being treated.

Cost

The per capita personnel cost is the salary of a clinician/assistant(s) team, prorated for 3-4 minutes. The per capita cost of supplies is less than $8 (yr. 2016), including the toothbrush. One GIC capsule is usually sufficient for all primary and/or permanent molars excluding third molars. Any remaining material can be used for premolars. If there are cavitation’s then additional capsules will be needed. The total cost in time and materials is less than an office fluoride-gel, rinse or varnish application with greater safety and much greater caries prevention and caries control. The difference would depend on the presence of other sources of fluoride in the water and diet. However, fluoride gel is most effective against interproximal caries and is ineffective against pit and fissure caries or open cavities. Caries reduction in these latter two sites is the specific objective of CCT although prevention of interproximal caries has been demonstrated, especially in the primary dentition and the proximal surface adjacent to a Class II CCT.

Discussion

Minimal treatment

Toothaches and fear of dental treatment still exist despite major advances in caries prevention, pain control and patient management. Conventional restorative treatment is not pleasant and does not prevent dental caries. There is support in the dental literature for a minimal interim, noninvasive treatment. This is especially important for children with high caries activity and for young children who can't understand or can't cooperate during restorative treatment. In 1908, Dr. G. V. Black described the management of caries in children as, "... one of the most difficult subjects in dentistry." (*Black, 1908*) His objectives were to arrest or delay the caries process without causing pain – the same objectives as CCT. The treatment he used combined two physically painless procedures – the proximal slice in which only enamel was removed, combined with cauterization and disinfection of the carious dentin with silver nitrate. Dr. Black's method did not remove caries and did not restore tooth form or function.

Table 5 (refer to page 312) contains quotations excerpted from Dr. Black's textbook. A complete reading of this chapter is preferable and will show that these quotations accurately represent his views and are not taken out of context. His observations are still applicable today, a century after they were written, and they provide a conceptual basis for CCT. In the 1960s, the United States Indian Health Service used Black's proximal slice to delay caries in primary molars of children living on remote Alaskan islands. In the 1970s Craig used silver fluoride for painless caries treatment of children living in Australian orphanages who were difficult to manage (*Craig, Powell, & Cooper, 1981*) (*Craig, 1986*) (*Craig, 1971*). In the 1990s, the World Health Organization recommended an atraumatic restorative treatment (ART), developed by Frencken and Pilot. ART applies glass ionomer cement over partially excavated caries using a low technology approach (*Barmes, 1993*). More recently, the Academy of Pediatric Dentistry has issued a policy on Interim Therapeutic Restoration (ITR) with similar goals and treatment methods as ART. The most recent iteration is SMART (Silver + Modified ART).

These examples show that a minimal treatment method is needed for: 1) poor countries with limited treatment capabilities; 2) inner city and rural children in industrialized countries where access to conventional care is limited; 3) affluent developing countries where caries experience is outpacing treatment capabilities (*Renson, 1989*); 4) home-bound individuals, and; 5) patients who need painless caries control pending their ability to withstand treatment that takes more time and patient management (e.g., toddlers and the mentally or physically disabled who otherwise require general anesthesia).

CCT history - 1985 to 1997

CCT was developed and used over a twelve-year period at the Saudi Aramco Oil Company in the Kingdom of Saudi Arabia. During that time there were over 200,000 teeth treated. CCT underwent a significant metamorphosis starting as an experimental, no-alternative treatment, then a treatment of last resort, and ultimately an official interim treatment in the written policy of the Dental Services Department. CCT was eventually used for all children who were scheduled for restorative treatment under general anesthesia and conceptually accepted by nine of the ten pediatric dentists. Despite the highly critical scrutiny of the general dentists, there were no verified reports of CCT being associated with adverse pulpal response or exacerbation of caries. Parents praised it and asked the Director of Dental Services why this procedure hadn't been offered before? Nevertheless, most of the general dentists did not include CCT in their treatment plans in any of its three functions: a fluoride reservoir, a long-term temporary treatment or a pit and fissure sealant. The only explanation for the acceptance by pedodontists and lack of acceptance by general dentists is that the former received a direct benefit by reducing complaints from parents whose children were on the OR waiting list while the latter saw no direct benefit to their practice and possibly additional work (treating the same tooth twice). Nonetheless, CCT was used in a large school program with 24,000 students and for drop-ins at the Maternal and Child Health clinics.

Necessity is the mother of invention

CCT was born of necessity due to a caries epidemic in an affluent population where high-quality dental care was readily accessible. The author was the preventive dentistry coordinator in a JCHA accredited group dental practice that had over 120 salaried dentists and dental hygienists providing highly subsidized comprehensive care for 50,000 employees and 150,000 dependents of a large company in the Kingdom of Saudi Arabia. Despite these favorable conditions, the increase in caries incidence continually outdistanced the ability to provide care, and the willingness of the parents to control their children's cariogenic lifestyle or to obtain care before a toothache occurred. As a result, the waiting list for restorative and surgical treatment lengthened and the number of emergency patients increased. In reaction to this epidemic, new staff members were hired, new facilities were constructed, and fees were increased (to pay for increased costs and to discourage unnecessary utilization). These measures did not control the excess demand for treatment of children with caries. The problem was so critical that a preventive dentistry coordinator was hired "to design and implement a comprehensive preventive program that will reduce the need for and cost of dental treatment." When faced with these conditions, the preventive dentist (the author of this paper) had no choice but to look for a procedure, like CCT, to restrain the caries process pending definitive restorative treatment.

Case histories

CCT was first tried on a five-year-old boy who was referred by a pediatric dentist for "preventive care." He was at the bottom of a one-year waiting list for comprehensive care under general anesthesia. The boy was screaming as his father carried him into the preventive dentistry clinic. They were accompanied by the boy's mother and his younger sister, who had never been to a dentist. He had a number of asymptomatic Black Class II open lesions and two missing primary first molars that had been emergency extractions.

This patient was the first of many in similar circumstances. It was obvious that the standard preventive services -- fluoride application and dental health education – were not going to avert additional emergency extractions during the next 8 to 12 months. Something more effective was needed to slow the caries process, to prevent food from being packed into the cavitation's, to prevent extractions, and to stop the cycle of crisis care. For the treatment to be effective and sustainable it had to be practical, which meant quick and painless. Without any other obvious alternative, there was nothing to lose by filling the open cavities with GIC to provide a continuous low concentration fluoride where otherwise there would be snack foods and sugary drinks.

The only possible disadvantage to this course of treatment was the expected criticism from colleagues for not excavating the caries and the possibility that the GIC would be quickly lost. The chance of exacerbating existing caries was remote. To provide no treatment or the previously ineffective treatments, were not acceptable alternatives. If GIC were retained for only one day it would more effective and safer than a 4-minutes fluoride gel application (*Craig, 1971*). If it stayed for weeks or months it could produce long-term caries control. Table 6 lists the advantages of CCT with emphasis on management of children, including those deemed "uncontrollable for standard restorative treatment."

The boy's parents accepted this temporary, untried measure in order to gain time until their child eventually reached the top of the OR waiting list. While this was being discussed with the parents, the boy stopped crying, but it was clear that any attempt to excavate caries or use standard equipment (operating chair and light or air-water spray and suction) would revive his fears based on his prior extractions, thus causing the preventive treatment to be aborted.

Consequently, the brother and sister were seated on their parents' laps, while their parents brushed their teeth without water or dentifrice. Having successfully completed this "procedure," they were shown the GIC "toothpaste mixing machine and the toothpaste" that would be placed on their teeth with a finger. To relieve the boy's anxiety, his innocent younger sister was treated first. One tooth was dried with gauze and GIC was quickly applied. Having seen his sister survive, the boy accepted the treatment. Two weeks later the GIC was still present, the parents were pleased, and the remaining teeth were easily treated.

On bi-monthly inspections most of the CCTs were intact and those that were lost were easily replaced or repaired, as needed. Eight months later, the scheduled restorative treatment was completed by a pediatric dentist <u>under local anesthesia,</u> <u>without additional tooth loss</u>.

The second patient was a four-year-old boy referred directly to the preventive clinic by an endodontist who was a social friend of the boy's father. The father adamantly refused to have his son subjected to "an injection and drilling" because his son's teeth weren't causing pain. Upon examination, six of his eight primary molars had obvious, Class II asymptomatic lesions. Two lesions were deep (one millimeter from the pulp on x-ray), two others were less extensive open cavitation's and two were only detectable on a radiograph. CCT was offered as a "temporary" alternative. The parents were fully informed about the unconventional nature of the treatment and they accepted the possibility of failure.

The treatment was slightly different from the first patient because this patient was able to cooperate although, like most children, he was wary. This allowed partial excavation with hand instruments, the same as what was later called Atraumatic Restorative Treatment (ART) and still later, Interim Therapeutic Restoration (ITR). The excavation was attempted primarily to deflect the anticipated criticism from other dentists. For these initial patients, the author accepted the conventional wisdom that removal of some caries might increase GIC bonding and retention. Excavation was stopped as soon as there was any sign of discomfort from the patient (real or imagined). This ensured that the parents would bring their child back for another appointment and that he would continue to cooperate. It could also be used to mollify dentists by showing an attempt was made to remove the caries. GIC was applied, but unlike ART, there was no attempt to restore tooth form and function i.e. to make it 'look' or 'function' like a restoration. This was 1985, before ART had been reported in the literature or known to the author.

For this second patient, it was anticipated there would be many short appointments to replace lost GIC (*Black, 1908*). As it turned out, the scheduled appointments were always missed. Instead, the patient was only brought in when partial loss of the CCT resulted in gingival irritation from food impaction. There was always some GIC remaining at the base of the cavity and the exposed caries was hard. Radiographs did not show any significant pulpal extension. Despite the fact that some of the CCTs had to be replaced, the parent could not be convinced to go to the pediatric dentist for conventional restorative treatments. Their reasons were the same as expressed at the first appointment – their son didn't have pain plus now the risk hadn't increased.

Despite re-educating the parents at each appointment (including appointments of his younger siblings), there was no improvement in the family's dental health habits. As a result, two years after the first appointment, one incipient Class II lesion had developed into a small open cavitation. Minimal excavation was performed and GIC was placed.

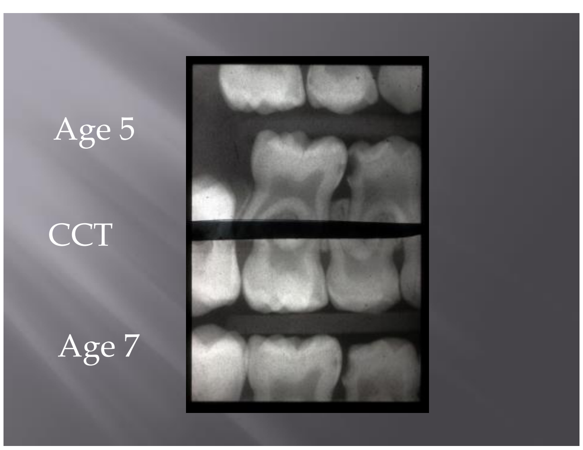


Figure 1: Radiographs before CCT at age 5 and after CCT at age 7.

Note: On the radiograph to the left (age 5) the 1st permanent molar had not erupted. On the lower radiograph, 2+ years later, the 1st perm. molar was fully erupted. After the top radiograph was taken, GIC was placed on all occlusals and the cavitation on the lower first primary molar. By age 7, the GIC is partially lost on the distal cavitation of the lower first primary molar but the caries appears to be remineralized and new secondary (reparative) dentin is protecting the pulp. Also, the radiolucency into the dentin on the adjacent mesial surface of the second mandibular primary molar is reduced in size plus secondary (reparative) dentin has been added and the radiolucency at the dej on the mesial of the maxillary first primary molar is no longer visible. There is no other plausible explanation for these changes seen at age seven than the one-time placement of the GIC-CCT at age five.

After two years caries was controlled **Fig. 1**. A chart review showed that two of the initial four CCTs had been retreated on one or more occasions, but caries had not progressed. The parents finally decided that their son, now eight, was 'old enough' to withstand the stress of conventional treatment, meaning an injection. However, after a thorough examination, the pediatric dentist decided there was no reason to remove the intact CCTs or to restore the teeth with conventional materials. Three years later, at age 11 (seven years after the initial visit), the entire primary dentition had exfoliated without the injection or the invasive treatment that his parents had feared and rejected. By age 13 he had a caries-free permanent dentition with intact GIC fluoride-releasing sealants. The high caries activity and high-risk behavior of both the child and the parents had not been appreciably improved but the consequences of their cariogenic habits had been successfully managed with a low cost, non-painful, non-invasive, minimal, long-term, so-called “interim” treatment regimen.

The Controversies

CCT is a multi-purpose, non-invasive, painless, preventive procedure that was well received by the patients, parents and dental program managers, while at the same time it was opposed or ignored by most clinicians, except for a few pediatric dentists. The controversies at the source of these contentious responses are listed in **Table 7** (refer to page 313). Each of these factors will now be discussed in detail.

No caries removal

Failure to remove caries is the root of the dentist’s opposition to CCT. With few exceptions, the cardinal injunction of restorative treatment is “remove all caries”. Dentists who break this rule face censure and ridicule from their peers. A review of the literature (from G. V. Black to Loesche to Mertz-Fairhurst) fails to support this time-honored rule and, in fact, it shows that covering or chemical treatment (e.g., silver nitrate or silver diamine fluoride) of visible caries can control caries progression, does not increase the probability of recurrent caries, and does not adversely affect the treatment prognosis.

The lack of a consistent rationale for this time-honored rule can be seen from the many exceptions to the rule: uncooperative children (aborted treatment), very deep cavities (indirect pulp cap) and inability to immediately treat the patient (*Nikiforuk, 1985*). These exceptions suggest that removing all caries or leaving caries intact for long periods is not as significant to the dentists as is the rule itself. So, it is breaking the rule that is the motivation for their censure and not the harmful consequences, against which they say they are protecting the patient. What is most important is the rule that says, “thou shalt follow standard practice regardless of the evidence or lack thereof.” The crime is to not follow the rule regardless of the negative consequences to the patient’s health. For example, how can it be acceptable to treat a single tooth and leave caries in the remaining teeth untreated (standard practice) while at the same time it is unacceptable to leave any visible trace of carious tooth structure once the treatment of a tooth is begun? Complete caries removal is deemed critical because it is thought that caries contains harmful bacteria that will allow the disease process to progress, yet it is a well-known fact that cariogenic bacteria remain under all standard restorations. Just as contradictory, how can an exception be made for leaving purportedly highly contagious carious dentin adjacent to the pulp when performing an indirect pulp cap, while allowing no exceptions for superficial caries? The standard answer for pulp capping is that deep caries cannot be removed without creating a pulp exposure, which, in turn, will necessitate pulp removal or mummification. The reasoning continues that it is better to give the tooth a chance to recover by itself and if the pulp dies (which includes pain), then the patient will willingly agree to more extensive treatment (direct pulp treatment), which they might have resisted if there had been no pain. The alternative is immediate pulp extirpation and root canal treatment on a tooth that the patient perceives as asymptomatic. This is much more difficult to explain to the patient because they think the dentist has made a mistake and is covering it up. The large cost of the RCT and crown adds to this notion. Even after the initial root canal treatment there can be painful sequelae, which the patient also blames on the dentist, if the tooth had not been painful when treatment was initiated. After all, before the patient entered the office that tooth had not have been painful or the pain was intermittent and tolerable. So, this is the rationale for leaving in caries when a lesion is near the pulp and it trumps the issue of leaving harmful bacteria dangerously close to the pulp.

What happens when caries is just into dentin? In this case it is relatively easy to remove, so dentists insist that it must be removed completely even though treating it with a silver medication and/or covering it with GIC will not harm the patient in the short-term or the long-term. This problem has become the subject of research because clinicians fear that they might be sealing in caries and could be censured for doing this or causing 'hidden caries'. Interestingly, they don't fear censure if secondary caries develops under restorations they have placed. This dichotomy demonstrates that their concerns about sealing in caries or removing all caries is not evidenced-based but is based on tradition, conventional wisdom and similar pragmatic factors, such as criticism by their peers or from a patient. Only recently has the Academy of Pediatric Dentistry approved what it calls, Interim Therapeutic Restoration (ITR) which they carefully distinguish from Atraumatic Restorative Treatment (ART) although they are the same treatment and very similar to CCT. The American Academy of Pediatric Dentistry has two policies that sanction covering caries, but both remove some decay.

Although CCT is not a restorative treatment, dentists still judge it by the standards for restorative treatment. The fact that CCT is patently safe and the patient has given informed consent are apparently of no importance (*Handelman, 1990*). A rule is a rule until the rule is changed and then that is the new rule - no exceptions. This is illogical and should be reconsidered in the light of present knowledge, especially for the treatment of patients whose access to conventional treatment is nonexistent, insufficient or indefinitely delayed and when it is clear that the prognosis will be enhanced by an alternative, albeit non-standard or interim

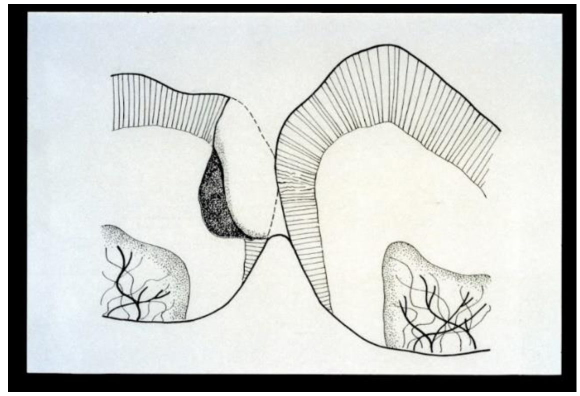


Figure 2: A sagittal section before application of GIC. Illustrated is a Class II cavity, bacteria, enamel, dentin, caries, pulp, gingival papilla and initial caries on the adjacent proximal surface.

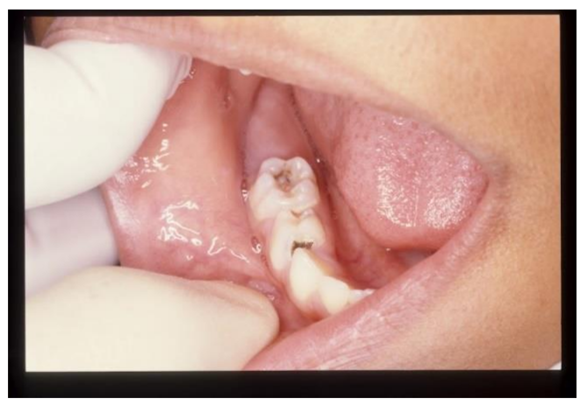


Figure 2a: A patient photograph of Fig. 2.

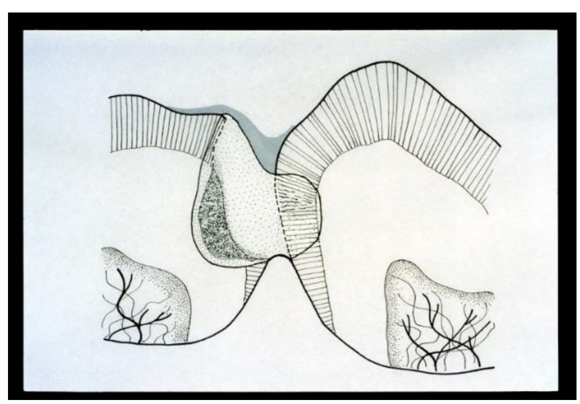


Figure 3: The same view as Figure 2 after placement of GIC and petrolatum.

treatment. Unfortunately, non-standard treatments are usually viewed as “second class” treatments and are deemed unacceptable, even for those who the dental profession already tacitly treat as “second-class” patients.

Figure 3a: A patient photograph of Fig. 3.

Figure 2 illustrates a sagittal section of a Black’s Class II cavitation in the distal of a mandibular first primary molar before the CCT procedure. **Figure 2a** is a photograph of a similar situation. The caries that remains is only partially demineralized. There is enamel demineralization on the proximal of the adjacent second primary molar but no cavitation. **Figure 3** illustrates CCT after GIC is placed over the caries and the surrounding enamel. **Figure 3a** is a photograph of a similar situation. Oral fluids are sealed out and bacteria are sealed in. Most studies have shown that sealing will arrest bacterial growth (*Handelman, Washburn, & Wopperer, 1976)* (*Going, Loesche, Grainger, & Syed, 1978*) (*Mertz-Fairhurst, Schuster, & Failhurst, 1986*) (*Mertz-Fairhurst, Curtis, Ergle, Rueggeberg, & Adair, 1998*). GIC provides a good, albeit not a perfect seal (*Kidd, 1978*) (*Thornton, Retief, & Bradley, 1988*). However, the fluoride that is continually released from the GIC neutralizes cariogenic bacteria (*Svanberg, Krasse, & Örnerfeldt, 1990*) (*Svanberg, Krasse, & Örnerfeldt, 1990*) (Berg, Farrell, & Brown, 1990) (*Forss, Jokinen, Spets-Happonen, Seppä, & Luoma, 1991*) and remineralizes tooth structure, including caries (*Siritapetawee et al., 1990*) (*Swift Jr., 1989*) (*Skartveit, 1990*) (*Ikeda et al., 1993*) (*Weerheijm, de Soet, van Amerongen, & de Graaff, 1993*) (*Benelli, Serra, Rodrigues, Jr., & Cury, 1993*). **Figure 4** is a photograph of a patient whose condition could have been prevented by CCT.

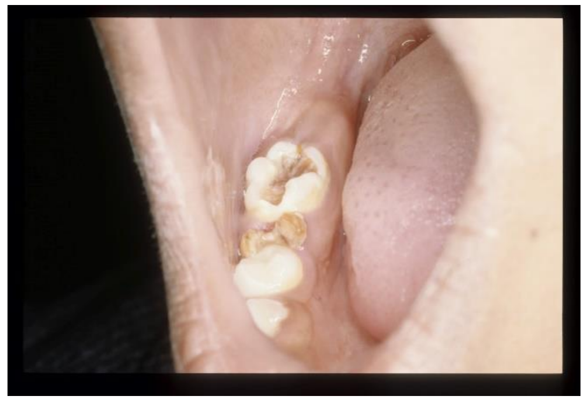


Figure 4: CCT could have prevented this.

There is no evidence-based advantage to removing the outer, surface layer of caries and leaving the inner layer, which is the procedure for ART and ITR. In fact, the demineralized dentin (caries) acts as a natural barrier between the outer environment and the pulp. Removing the outer layer remove some of the bacteria but it also reduces the thickness of the layer over the pulp. If the objective of caries removal is to stop the caries process by eliminating the bacteria, then this approach is patently false without the use of an antibacterial agent, such as silver nitrate or silver diamine fluoride. The fluoride in GIC is an antibacterial agent. It is a fact that the remaining bacteria are cariogenic only if they have a continuous substrate from which they can produce the acid that demineralizes enamel and dentin. This is the justification for dietary changes in caries prevention and is also justification for sealing in the remaining cariogenic bacteria, which denies them the necessary substrate. The placement of GIC accomplishes this objective. If pulp protection is the objective then decreasing the amount of tooth structure over the pulp, even the partially demineralized tooth structure, is unnecessary, counterproductive and probably harmful.

Effect on the pulp

CCT will not cause pulpal irritation or pain.

1. Teeth with a high risk for a pulp reaction are eliminated as candidates for CCT (See **Table 2**; refer to page 311). The lack of signs and symptoms of pulpal pathosis indicates that the pulp is probably vital in spite of high-risk conditions.
2. GIC is considered one of the most biocompatible of current treatment materials (Dijken, 1992) (*Croll, Riesenberger, & Miller, 1988*) (*Gotjamanos, 1996*).

3. Unlike restorative treatment, there is no local anesthesia to mask the pain emanating from a pulpal reaction to the treatment.

4. CCT does not produce pulpal pressure, dehydration, or significant temperature changes, as do many procedures and materials.

5. The caries and the remaining dentin (both intact and partially demineralized) are protective barriers between the GIC and the pulp. If all the caries were removed, the newly exposed dentinal tubules would provide a direct avenue to the pulp for bacteria and toxic elements in the treatment materials (*Stanley, 1990*). This is why cavity liners are so popular and necessary.

6. GIC stops microleakage of cariogenic nutrients and allows less microleakage than most other treatment materials (*Kidd, 1978*) (*Swift Jr. & LeValley, 1992*) (*Kidd, Toffenetti, & Mjor, 1992*).

7. GIC releases fluoride to counteract the effects of any microleakage.

8. If neither CCT nor conventional treatment is performed, then the cavities will be constantly filled with fermentable dietary products, and caries will progress unless the patient or parent cleans if carefully and frequently. Otherwise, a painful abscess will occur followed by a traumatic emergency extraction.

Gingival contact

A Class II CCT is less likely to cause gingivitis than a Class II amalgam restoration. GIC actually reduces plaque, especially mutans Streptococci, because of its fluoride release (*Leinfelder, 1993*) (*DeSchepper, White, & von der Lehr, 1989*). CCT eliminates the food trap and locates a fluoride reservoir where caries risk is the highest – the proximal surface of the adjacent tooth (**Fig. 2**) (*Telford, 1983*) (*Tanaka, 1990*) (*Derkson, 1989*) (*Stratman & Donly, N.D.*) (*Svanberg, 1992*). This benefit clearly outweighs the loss of the ability to floss between these teeth.

A matrix band is not used because it would defeat the purpose by:

1. eliminating the added adhesion to the adjacent proximal surface;

2. eliminating the natural retentive undercut;

3. increasing treatment time;

4. precipitating gingival bleeding and

5. creating unnecessary patient management problems.

Conventional wisdom suggests that the rough GIC surface would encourage plaque development, but this is not the case because the fluoride release is toxic to the bacteria.

Retention

Retention for CCT ranges from days to years, depending on treatment conditions, occlusal forces, the patient's diet and the definition of retention. The GIC surface is eroded by acids, including those found in soft drinks. As might be expected, retention is greatest where there is no occlusion. This is one of the reasons why occlusal form and function are not restored in CCT. As a sealant, the long-term macroscopic retention of GIC is not as good as a Bis-GMA resin sealant (*Nakornchai, 1990*) (*Forss, 1991*) (*Mejare, I. & Mjor, I. A., 1990*). However, there is a high degree of microscopic retention of GIC particles in the pits and fissures and as fused GIC/tooth structure, both providing long-term caries protection via low-concentration fluoride release (*Mejare, I. & Mjor, I. A., 1990*) (*Seppa & Forss, 1991*). Thus, caries prevention and arrest, rather than visible retention, are the important measurements of effectiveness.

Effectiveness

The World Health Organization has studied and endorsed an atraumatic restorative treatment (ART), which uses GIC and has the same rationale as CCT. The American Academy of Pediatric Dentistry and the U.S.P.H.S Indian Health Service have approved an Interim Therapeutic Restoration (ITR). Both have the same rational and almost the same treatment as CCT with two significant differences.

1. CCT purposely does not remove caries while ART/ITR attempts to remove caries without anesthesia and without inducing pain. However, there is no objective way to determine when removal of caries will induce pain, so it is likely that some pain will be induced from the last 'scoop' of decay.

2. The only goal of CCT is caries control, while restoration of form and function are goals of ART/ITR. ART has been evaluated as a restoration and the results are good when compared with conventional amalgam restorations (*Pilot et al., 1993*). ITR is a policy but, like CCT, it isn't evidence-based.

The major advantage of ART over conventional restorative treatment (CRT) is the lower training requirement for the clinician and the ability to be performed in less sophisticated circumstances. If ART were evaluated only for caries control (vs. retention, form etc.), the results would probably be even better. **Table 8** (refer to pages 313-314) is a procedural comparison of CCT, ART/ITR, ABT (Antibacterial Treatment such as, silver nitrate and silver diamine fluoride, CHX-chlorhexidine, F-fluoride, Povidone-Iodine, Xylitol) and CRT (Conventional Restorative Treatments).

The concepts, methods and materials of CCT are proven as separate elements but the combination used in CCT has not been specifically studied. Studies were not permitted at the organization where it was developed because research was not its mission and it didn't want the paying patient to be research subjects. Although CCT was demonstrated at an International Conference, no one has been willing to test it because they considered it too controversial. It will be tested only when it is perceived that the need is so great (high caries and no treatment funds) that there will be no other choice. We are approaching that point in specific populations in the United States and have long ago reached this point in most of the world. The most important element is the anticaries characteristic of GIC, which have been widely reported (*Lacy, 1994*). GIC sealants have been shown to equal or exceed Bis-GMA in caries prevention despite poorer retention (*Mejare, I. & Mjor, I. A., 1990*). GIC is bacteriostatic for mutans Streptococcus, the primary bacterium associated with caries initiation (*Svanberg, Krasse, & Örnerfeldt, 1990)* (*Svanberg, Krasse, & Örnerfeldt, 1990*) (*Berg, Farrell, & Brown, 1990*) (*Forss, Jokinen, Spets-Happonen, Seppä, & Luoma, 1991*). Sealing over caries reduces caries activity by denying substrate to the bacteria. In addition to aiding remineralization, fluoride, and perhaps other elements in GIC (*Kleber & Putt, 1992*) (*Kleber, 1993*) reduce the number of bacteria and their ability to produce acid (*Weerheijm, de Soet, van Amerongen, & de Graaff, 1993*). A GIC fluoride reservoir is the ultimate method for fluoride application – always present at a low/safe concentration when demineralization is occurring (*Stamm, 1993*) (*Axelsson, 1993*). The fluoride that leaches out of GIC is replaced by fluoride from any external source with a higher concentration e.g., dentifrice (*Strang et al., 1993*) (*Marinelli & Donly, 1993*) (*Seppa & Ogaard, 1993*). If GIC were only retained for one day (1440 minutes), the fluoride contact-time at high-risk sites would be up to 360 times more than a four-minute fluoride-gel treatment, plus much safer and more effective.

Unlike restorative treatments or even resin sealants, CCT can have a successful outcome even if GIC is not completely retained (Stamm, 1993) (Hatibovic-Kofman & Koch, 1991). Partially-retained GIC acts as a fluoride reservoir and is not a source of increased caries-risk like a fractured amalgam or a leaking Bis-GMA sealant. In one study, GIC was completely removed one month after placement and the level of fluoride in the enamel remained above normal for over six months compared to two weeks for an application of high-concentration fluoride gel (*Komatusu et al., 1990*).

Informed consent

Informing patients that the tooth decay has not been removed and explaining what might happen if definitive treatment isn't obtained, does not guarantee that the patients will seek follow-up care. Regardless of the procedure, there will always be the problem of patient's failing to follow clearly explained instructions for follow-up care. A misunderstanding about the treatment objectives is the least likely reason for failure to complete a treatment plan. Patients often fail to return for definitive treatment because: 1) their initial complaint (pain or lost filling) has been resolved; 2) their treatment objectives are different from the dentist's and; 3) they want to avoid further discomfort or expense. In addition, there are always situations where the parents will not give consent for specific treatment for fear of how their child might react. In these circumstances, CCT is a far superior choice to no treatment at all and can be completed at the initial appointment.

Follow-up care

What happens when a patient with a CCT goes to another dentist and presents with GIC on an asymptomatic tooth? The clinician must first determine if the GIC is:

1. a sealant;
2. a poorly performed definitive restoration;
3. a temporary restoration or;

4. something else.

The dentist should question the patient and the patient/parent should be able to respond with valuable information. If caries is directly visible or there is radiolucency on the radiograph, then a determination must be made whether there is active caries. These are diagnostic questions that dentists normally don't have to ask because they start with the assumption that all the caries has been removed and, if not, that all caries is active and should be completely removed.

These questions are not as difficult or troublesome as they first appear. The shape and size of the GIC on the radiograph will indicate if it is a sealant, CCT or a restoration. The amount of remaining dentin over the pulp is the most important factor in deciding on a treatment plan. For a shallow and intact Class 1 GIC there is no treatment required whether it is a sealant, a CCT or a restoration. A follow-up radiograph in 6 months will indicate if there is any change consistent with active caries.

<u>A Class II CCT in a permanent tooth should be replaced with a definitive restoration regardless of signs or symptoms</u>. This is because the CCT is not a restoration and will not last 10 - 70 years, the potential for a definitive restoration. This rule doesn't apply to primary teeth because their lifetime is much shorter, 6-10 years and the roots begin to resorb three year before exfoliation. In primary teeth, if there is radiolucency under the GIC and there is less than one millimeter of remaining dentin, then the CCT could be replaced with a restoration unless root resorption is more than 50 percent. If the radiograph is inconclusive on the presence of caries, then there are two options: 1) monitor with a radiograph in 6 month or 2) remove the GIC to examine for caries. Other factors being equal, clinicians familiar with CCT are more likely to choose option 1 and those with less experience will choose option 2. If there is a partial loss of GIC and no other reason for retreatment then the defect can be repaired by direct addition of GIC (*Komatusu et al., 1993*).

Conflicting views

Although dental health is the shared goal of dentists and patients, they often have conflicting views about how to reach that goal. From the dentists' viewpoint, caries could be eliminated if patients flossed and brushed their teeth daily, optimized the use of fluoride, didn't snack, and had regular dental appointments. In the patients' ideal world, there would be no oral hygiene requirements, no restrictions on eating, no toothaches and no dental appointments. Dentists want patients to take full responsibility for their dental health and patients want dentists to provide an easy, foolproof, low-cost solution for a problem for which they feel the punishment (toothaches and dental treatment) doesn't fit the crime (snacking and inconsistent oral hygiene). These opposing views for reaching a shared goal hamper cooperation between the clinician and the patient. If each would forgo their "all or nothing" attitude, then their viewpoints could be partially reconciled by accepting caries control as a realistic intermediate goal i.e., not eliminating caries but preventing the serious sequelae - pain, tooth loss and loss of arch space, at least until the patient decides a more definitive treatment is desirable and affordable.

Dental profession's reputation

Dentists have expressed concern that CCT will damage the dental profession's reputation. Among the comments have been: "it is incomplete treatment that must be redone", "it gives the patient a false sense of security" and "patients deserve the best and nothing less!"

Although dentists have been uncomfortable with the CCT objectives and limitations, the patients have been very accepting. CCT won't damage the reputation of the profession if patients are fully informed, which is true of any treatment.

Ethical issues

The CCT procedure raises important ethical questions:

Can a dentist leave caries untreated knowing that the patient might not return for follow-up care?

Does the dental profession have any responsibility for sponsoring outreach programs and treatments for children whose parents do not, or cannot, obtain conventional care for them?

Do dentists have an obligation to offer a minimal treatment that can prevent pain and tooth loss even if it isn't a definitive (comprehensive) treatment?

Should dentists wait until parents bring their children for emergency extractions before initiating care or should dentists seek out high-risk children and provide low-cost CCT with parental consent?

It is difficult to consider these ethical questions realistically unless faced every day with real children who have gross caries and real parents who do not understand or do not want to understand or think they can't afford to understand, the consequences of failing to take action to stop, or at least control, the caries process and to treat existing lesions.
The dental profession must have an alternative between the extremes of crisis care and comprehensive care. To meet its ethical and professional responsibilities, dentists must have an interim caries control option even though the results seem sub-optimal (Black, 1908). A preventable toothache is not only parental neglect; it is also professional neglect (*Jessee, 1993*).

Evaluation of CCT

CCT should be evaluated on its stated objectives:

1. to prevent caries in posterior teeth,
2. to prevent premature loss of primary teeth,
3. to slow or arrest the caries process, and
4. to prevent a painful tooth or painful tooth treatment.

The potential for negative side effects and cost-effectiveness should also be evaluated. However, CCT should not be evaluated on criteria for a restoration (caries removal, GIC retention, form, marginal integrity, occlusal function) because these are not germane to its objectives.

Ideally, a research study should compare CCT, ART, ABT (antibacterial treatment), SMART (antibacterial treatment + CCT) and CRT (**Table 8**; refer to pages 313-314). Outcomes to be compared would be: symptoms, retention, pulpal infection, tooth loss, cost-effectiveness, patient acceptance, and ease of application in both clinical and non-clinical settings, caries prevention, caries progression and prevention of premature tooth loss. The controlled variables would be: tooth type, post-eruption tooth age, salivary fluoride level, cariogenic bacteria, caries-pulp distance and stage of root resorption in primary teeth.

Resolution of the controversies

Dentists criticize CCT because it is used to treat lesions for which a restoration is the conventional treatment. They fear that the patient will think CCT is a definitive treatment and the results will damage dentistry's reputation. This fear can be resolved by informed consent because ultimately the choice and responsibility belongs with the parent or patient. It would also help if dentists had a better understanding of the caries process, so they could feel more comfortable about situations in which caries removal is not the treatment of choice.

Disease control and cavity restoration are complementary rather than conflicting objectives. Theoretically, there would be no controversy if CCT were retained for only a short time and caries underneath was visible or detectible. Unfortunately, complete caries removal and ideal cavity restoration do not prevent future disease. In the long-term, a significant proportion of these "ideally treated" teeth eventually have recurrent caries, endodontic therapy or extraction.

CCT has been developed to meet the needs of most of the world's population, especially children, who have untreated caries without access to comprehensive care. A dentist, whose patients are affluent and have a low caries rate, think CCT is unnecessary or even poor practice. However, in every community there are sub-populations with high caries rates for whom only emergency care is provided. There are also communities where the caries activity is so severe that excellent restorative treatment is destroyed by recurrent caries and there are still other communities where conventional treatment services are absent or can be only provided under general anesthesia. In these circumstances, CCT neither conflicts with nor should be misunderstood as a substitute for a restorative service.

The need is great, and the controversy could be resolved by conducting definitive studies that take into account different levels of caries activity, treatment availability and concerns of patients. The ethical issues can only be resolved through open discussion.

Conclusion

CCT is a multi-purpose procedure that uses GIC to prevent and control caries. It is an adaptation of accepted concepts, methods and materials. This simple, low-cost procedure combines a fluoride-reservoir, sealant and caries control treatment into one procedure. CCT needs to be studied under controlled conditions to clearly establish its safety and effectiveness in comparison with alternative treatments. CCT is controversial among dentists and raises a number of important technical and ethical issues that have wider implications for preventive and restorative dentistry.

TABLES

Indications:
- All Class I tooth surfaces without signs of caries.
- All cavitated tooth surfaces, except teeth with:

Contraindications:
- History of tooth pain.
- Probable need of pulp therapy or extraction
- Signs or symptom of an abscess.
- Impossible to treat, e.g., debris, blood.
- Existing restoration.

Table 1: Indications and Contraindications for CCT

- type 2 glass ionomer cement (capsule system, 1 per patient)
- capsule activator and applicator (2 sets per clinician)
- triturator (1 per clinician)
- petrolatum in squeezable tube
- gauze (4 pieces per patient)
- toothbrush (1 per patient which the patient keeps)
- infection control supplies (gloves, tray coverings, glasses, plastic disposable bag)
- articulation paper (ideally not used)
- cleoid/discoid carver (three per clinician and ideally not used)

Table 2: Equipment and Supplies for the CCT Procedure

hydrophilic set	bacteriostatic	fast setting
chemical bonding	fluoride release	biocompatible
compressible		

Table 3: Properties of Type 2 Glass Ionomer Cement

A.	Debride the occlusal surfaces and cavitation's with a toothbrush.
B.	Reduce moisture on occlusal surfaces with gauze.
C.	Press GIC into cavitation's, pits and fissures.
D.	Coat GIC before set with petrolatum.
E.	Tap teeth together in centric occlusion.
F.	Keep teeth apart until initial set of GIC (five minutes from start of mix).

Table 4: Main Steps in the CCT Procedure

safe	painless	low skill	non-threatening
fast	low risk	effective	expanded function
simple	low-cost	multi-purpose	low technology

Table 5: Advantages of Caries Control Treatment

- Caries is not excavated.
- Plaque and saliva are not completely removed.
- A finger is used to place GIC.
- GIC is placed over caries.
- Visible long-term retention of GIC is less than other procedures.
- GIC is left in direct contact with gingiva.
- Flossing between posterior teeth be prevented.
- Manufacturer's recommended instructions are not followed.

Table 6: Contentious Facts of the CCT Procedure

Parents are likely to put off all effort at treatment until the child has had a sleepless night with a toothache. (p. 256) Much too frequently the dentist's first meeting with a child is when it (sic) has been wrought up with pain until its nerve endings are all on the alert ready to take fright at the least suggestion of further suffering. (p. 235) We must temporize in our treatment. How can we temporize to our advantage, becomes the question? (p. 248) Leave the decayed material in the dentin where it is. Do not disturb it or attempt to remove it. The removal of this is particularly painful to the child. (p. 249) If some decay is left or some dentin is exposed, it should be treated with silver nitrate. The object in this treatment is to fill the part of the dentin softened by decay with the insoluble salt of silver ... and incidentally to destroy the organisms in it. (p. 249) Generally, decay is effectually (sic) stopped by this treatment if the teeth and cut surfaces are kept fairly well cleaned. (p. 250) and the teeth, although mutilated and out of shape, will be useful to the time of their shedding. (p.251) If decay is again starting up in some part of a surface that has been treated in this way, treat it again and stop it again, and again, if necessary. (p.252) We will not always succeed well with this process; sometimes the sensitiveness will remain and hinder us from making a sufficient excavation, but the case will be the better for the limiting of the decay that will occur, even if we do not entirely succeed. (p. 253-254)

Table 7: Quotations from G. V. Black on the Management of Children's Teeth in A Work on Operative Dentistry in Two Volumes, Volume I. p. 235-257(1908).

AREAS OF COMPARISON		CCT	ABT	SMART	ART/ ITR	CRT
Objectives	• painless procedure..................................	yes	yes	yes	almost	no
	• prevents caries..	yes	yes	yes	yes	no
	• delays caries recurrence..........................	yes	yes	yes	yes	yes
	• arrests caries	yes	yes	yes	yes	no
	• prevents or delays tooth loss.................	yes	yes	yes	yes	yes
	• removes decay	no	no	no	some	all
	• removes cariogenic bacteria	no	no	no	some	some
	• kills cariogenic bacteria	no	yes	yes	no	no
	• covers decay	yes	yes	yes	yes	no
	• repairs tooth form and occlusion...........	no	no	yes	yes	yes
Treatment Criteria	• all teeth except those that are painful or abscessed............................	yes	yes	yes	yes	yes
Procedure	• local anesthesia.......................................	no	no	no	no	yes
	• excavates all caries	no	no	no	no	yes
	• partial caries excavation	no	no	no	yes	no
	• no caries removal...............................	yes	yes	yes	no	no
	• prepare cavity for restoration.................	no	no	no	yes	yes
		no	no	--	yes	no

	• restore form and function with GIC......... • restore form and function w amal/comp. • apply GIC over caries and pits/fissures • single visit for all carious teeth............	no yes yes	no -- yes	no yes yes	no yes yes	yes no no
Utilities	• electricity... • compressed air .... • water under pressure..........................	no no no	no yes no	yes yes no	yes yes yes	yes yes yes
Personnel	• dentist... • expanded functions for auxiliaries.......... • dental assistant required..........................	no yes yes	no yes no	no yes yes	no yes yes	yes yes yes
Equipment	• operating light and dental chair.............. • mechanical mixer................................. • water spray... • forced air... • suction..	no yes no no no	no no no yes no	no yes ? yes no	yes no yes yes no	yes yes yes yes yes
Instruments	• standard restorative hand instruments...	no	no	no	yes	yes
Infection Control	• instrument sterilization required............	no	no	no	yes	yes
Material	• GIC - capsule system, self-cure............... • GIC - hand mix, self-cure.......................... • amalgam, composite, gold.......................	yes no no	no no no	yes yes no	yes yes no	no no yes
Treatment Time	• three – five minutes per patient............. • fifteen minutes per patient • over fifteen minutes per tooth................	yes no no	yes no no	no yes no	no no yes	no no yes

Table 8: Comparison of CCT (Caries Control Treatment)
ABT (Anti-Bacterial Treatment e.g., SN, SDF, CHX)
ART (Atraumatic Restorative Treatment + GIC sealant)
ITR (Interim Therapeutic Restoration – ART without GIC sealant)
SMART (Silver Modified ART = ABT/SDF/SN + ART/ITR without excavation)
CRT (Conventional Restorative Treatment)

References

Allukian, M. (1993). Introduction in Oral Disease: The neglected epidemic – what can be done?. Journal of Public Health Dentistry, 53, 45.

Axelsson, P. (1993). Current role of pharmaceuticals in prevention of caries and periodontal disease. International Journal of Dentistry, 43(5), 473–482.

Barmes, D. (1993). Towards a better oral health future. World Health Organization - Oral Health Programme.

Benelli, E. M., Serra, M. C., Rodrigues, Jr., A. L., & Cury, J. A. (1993). In situ Anticariogenic Potential of Glass lonomer Cement. Caries Research, 27(4), 280–284. https://doi.org/10.1159/000261551

Berg, J. H., Farrell, J. E., & Brown, L. R. (1990). Class II glass ionomer/silver cermet restorations and their effect on interproximal growth of mutans streptococci. Pediatric Dentistry, 12(1), 20–23.

Black, G. V. (1908). A Work on Operative Dentistry, The Pathology of the Hard Tissues of the Teeth. 1st ed., vol. 1, Chicago, Medico-Dental Publishing Company, pp. 235–257.

Craig, G. G. (1971). Prolonged fluoride application. Community Dentistry and Oral Epidemiology.

Craig, G. G. (1986). Operative Dentistry Manual. University of Sydney. School of Dentistry.

Craig, G. G., Powell, K. R., & Cooper, M. H. (1981). Caries progression in primary molars: 24-month results from a minimal treatment programme. Community Dentistry and Oral Epidemiology, 9(6), 260–265. https://doi.org/10.1111/j.1600-0528.1981.tb00342.x

Croll, T. P., Riesenberger, R. E., & Miller, A. S. (1988). Clinical and histologic observations of glass ionomer-silver cermet restorations in six human primary molars. Quintessence International, 19(12), 911–919.

Derkson, G. D., Richardson, A. S., Jinks, G. M. (1989). Clinical evaluation of a restoration containing fluoride: two-year results. Pediatric Dentistry, 11, 286-290.

DeSchepper, E. J., White, R. R., & von der Lehr, W. (1989). Antibacterial effects of glass ionomer. American Journal of Dentistry, 2(2), 51–56.

Dijken, J. (1992). Three-year evaluation of effect of surface conditioning on bonding of glass ionomer cement in cervical abrasion lesions. European Journal of Oral Sciences, 100(2), 133–135. https://doi.org/10.1111/j.1600-0722.1992.tb01726.x

Feigal, R. J., Hitt, J., & Splieth, C. (1993). Retaining Sealant on Salivary Contaminated Enamel. The Journal of the American Dental Association, 124(3), 88–97. https://doi.org/10.14219/jada.archive.1993.0069

Flanders, R. A. (1988). School Dental Health in Honduras. Journal of Public Health Dentistry, 48(3), 168–171. https://doi.org/10.1111/j.1752-7325.1988.tb03187.x

Forss, H., Jokinen, J., Spets-Happonen, S., Seppä, L., & Luoma, H. (1991). Fluoride and Mutans Streptococci in Plaque Grown on Glass Ionomer and Composite. Caries Research, 25(6), 454–458. https://doi.org/10.1159/000261410

Forss, Helena, Saarni, U.-M., & Seppa, L. (1994). Comparison of glass-ionomer and resin-based fissure sealants: a 2-year clinical trial. Community Dentistry and Oral Epidemiology, 22(1), 21–24. https://doi.org/10.1111/j.1600-0528.1994.tb01563.x

Going, R. E., Loesche, W. J., Grainger, D. A., & Syed, S. A. (1978). The viability of microorganisms in carious lesions five years after covering with a fissure sealant. The Journal of the American Dental Association, 97(3), 455–462. https://doi.org/10.14219/jada.archive.1978.0327

Gotjamanos, T. (1996). Pulp response in primary teeth with deep residual caries treated with silver fluoride and glass ionomer cement ('atraumatic' technique). Australian Dental Journal, 41(5), 328–334. https://doi.org/10.1111/j.1834-7819.1996.tb03142.x

Handelman, S. L. (1990). Dentists' preferences in management of incipient caries in young adults. Journal of Dental Research, 69(Special Issue), 281.

Handelman, S. L., Washburn, F., & Wopperer, P. (1976). Two-year report of sealant effect on bacteria in dental caries. The Journal of the American Dental Association, 93(5), 967–970. https://doi.org/10.14219/jada.archive.1976.0007

Hatibovic-Kofman, S., & Koch, G. (1991). Fluoride release from glass ionomer cement in vivo and in vitro. Swedish Dental Journal, 15(6), 253–258.

Ikeda, M. et al. (1993). In vivo fluoride uptake by dentine from fluoride-releasing glass ionomer. Caries Research, Abstract 103, 236.

Indian Health Service. (2010). IHS Early Childhood Caries Collaborative. Retrieved from Ihs.gov website: http://www.ihs.gov/doh/index.cfm?fuseaction=ecc.display

Jessee, S. A. (1993). The neglect of our youth: A dental perspective. ASDC Journal of Dentistry for Children, 60(4), 361–364.

Kidd, E. A. (1978). Cavity sealing ability of composite and glass ionomer cement restorations. An assessment in vitro. British Dental Journal, 144(5), 139–142. https://doi.org/10.1038/sj.bdj.4804047

Kidd, E. A., Toffenetti, F., & Mjor, I. A. (1992). Secondary Caries. International Dental Journal, 42(3), 127–138.

Kleber, C. J., & Putt, M. S. (1992). Inhibitory Effect of Aluminum on Fissure Caries Formation in Rats (Short Communication). Caries Research, 26(1), 53–55. https://doi.org/10.1159/000261427

Kleber, C. J., Putt, M. S., Milleman, J. L. (1993). Dose response of aluminum in dentifrice on rat dental caries formation. Journal of Dental Research, Abstract 102, 236.

Komatusu, H. et al. (1990). Retention of fluoride in enamel after removal of applied glass-ionomer cement. Journal of Dental Research, 68, 4, Abstract 893.

Komatusu, H. et al. (1993). Caries preventive effect of glass-ionomer sealant reapplications: 3-year results. Journal of Dental Research, IADR Abstract 217, 131.

Lacy, AM (1994). Observations on glass ionomer [letter to the editor]. Journal of American Dentistry, 125, 2, 126-128.

Leinfelder, K. F. (1993). Glass Ionomers: Current Clinical Developments. The Journal of the American Dental Association, 124(9), 62–64. https://doi.org/10.14219/jada.archive.1993.0180

Marinelli, C. B., Donly, K. J. (1993). Effects of a fluoridated dentifrice on fluoride release of composite resin and glass ionomer cement. Journal of Dental Research, Abstract 1707, 317.

Marthaler, T. M. (1983). Explanations for changing patterns of disease in the western world. In Cariology Today, International Congress, 13-25.

McDonald, S. P., & Sheiham, A. (1994). A clinical comparison of non-traumatic methods of treating dental caries. International Dental Journal, 44(5), 465–470.

McKnight-Hanes, C., & Whitford, G. M. (1992). Fluoride Release from Three Glass Ionomer Materials and the Effects of Varnishing with or without Finishing. Caries Research, 26(5), 345–350. https://doi.org/10.1159/000261466

McLean, J. W., & Wilson, A. D. (1974). Fissure sealing and filling with an adhesive glass-ionomer cement. British Dental Journal, 136(7), 269–276. https://doi.org/10.1038/sj.bdj.4803174

Mejare, I. & Mjor, I. A. (1990). Glass ionomer and resin-based fissure sealants: a clinical study. European Journal of Oral Sciences, 98(4), 345–350. https://doi.org/10.1111/j.1600-0722.1990.tb00983.x

Mertz-Fairhurst, E. J., Curtis, J. W., Ergle, J. W., Rueggeberg, F. A., & Adair, S. M. (1998). Ultraconservative and Cariostatic Sealed Restorations: Results at Year 10. The Journal of the American Dental Association, 129(1), 55–66. https://doi.org/10.14219/jada.archive.1998.0022

Mertz-Fairhurst, E. J., Schuster, G. S., & Failhurst, C. W. (1986). Arresting caries by sealants: results of a clinical study. The Journal of the American Dental Association, 112(2), 194–197. https://doi.org/10.14219/jada.archive.1986.0340

Mount, GJ. (1984): Glass Ionomer Cements: Clinical Considerations. In: Clark, J.W. (ed), Clinical Dentistry, Vol. 4, Chap. 20A, Hagerstown: Harper Row, 1-22

Nakornchai, S. (1990). A comparison of retention in two types of sealants. Journal of Dental Research, 68, 4, Abstract 75.

Nikiforuk, G. (1985). Understanding dental caries. Volume 1 : etiology and mechanisms ; basic and clinical aspects. (pp. 286–287). Basel: Karger.

Pilot, T., Frencken, J., Phantumvanit, P., Songpaisan, Y. (1993). Development of a model for primary oral health care in refugees and displaced persons encampments. Report on fifth six months. WHO Collaborating Centre for Oral Health Services Research, November 1993.

Renson, C. E. (1989). Global changes in caries prevalence and dental manpower requirements: 1. Assembling and analyzing the data. Dental Update, 16(7), 287–288, 291–293, 296–298.

Saleh, L. A., Khalil, M. F. (1994). The effect of different protective coatings on the surface hardness of glass ionomer cements. Saudi Dental Journal, 6, 3-7.

Seeholzer, H. W., & Dasch, W. (1988). Banding with a glass ionomer cement. Journal of Clinical Orthodontics, 22(3), 165–169.

Seppa, L., & Forss, H. (1991). Resistance of occlusal fissures to demineralization after loss of glass ionomer sealants in vitro. Pediatric Dentistry, 13(1), 39–42.

Seppa, L., et al. (1992). Fluoride content of enamel and plaque in teeth adjacent to glass ionomer restorations. Journal of Dental Research, Abstract 43.

Seppa, L., Ogaard, B. (1993). The effect of fluoride application on fluoride release and antimicroial property on glass-ionomer in vitro. Journal of Dental Research, IADR Abstract 949, 222.

Siritapetawee, M. et al. (1990). Salivary fluoride released by glass ionomer or HF sealants. Journal of Dental Research, Abstract 81, 1106.

Skartveit, L., Tveit, A. B., Totdal, B., Ovrebo, R., & Raadal, M. (1990). In vivo fluoride uptake in enamel and dentin from fluoride-containing materials. ASDC Journal of Dentistry for Children, 57(2), 97–100.

Smith, A. C., & Lang, W. P. (1993). CPITN, DMFT, and treatment requirements in a Nicaraguan population. Community Dentistry and Oral Epidemiology, 21(4), 190–193. https://doi.org/10.1111/j.1600-0528.1993.tb00754.x

Stamm, J. W. (1993). The value of dentifrices and mouthrinses in caries prevention. International Dental Journal, 43(6 Supplemental 1), 517–527.

Stanley, H. R. (1990). Pulpal Responses to Ionomer Cements—Biological Characteristics. The Journal of the American Dental Association, 120(1), 25–29. https://doi.org/10.14219/jada.archive.1990.0013

Strang, R. et al. (1993). Fluoride uptake and release from a glass ionomer. Caries Research, Abstract 102, 236.

Stratman, R. G. and Donly, K. J. (n.d.). Enamel remineralization on teeth adjacent to and contacting Class II glass ionomer restorations. Journal of Dental Research, IADR Abstract 1709, 317.

Svanberg, M. (1992). Class II Amalgam Restorations, Glass-Ionomer Tunnel Restorations, and Caries Development on Adjacent Tooth Surfaces: A 3-Year Clinical Study. Caries Research, 26(4), 315–317. https://doi.org/10.1159/000261459

Svanberg, M., Krasse, B., & Örnerfeldt, H.-O. (1990). Mutans Streptococci in Interproximal Plaque from Amalgam and Glass Ionomer Restorations. Caries Research, 24(2), 133–136. https://doi.org/10.1159/000261255

Svanberg, M., Mjör, I. A., & Ørstavik, D. (1990). Mutans Streptococci in Plaque from Margins of Amalgam, Composite, and Glass-ionomer Restorations. Journal of Dental Research, 69(3), 861–864. https://doi.org/10.1177/00220345900690030601

Swift Jr., E. J. (1989). Effects of glass ionomers on recurrent caries. Operative Dentistry, 14(1), 40–43.

Swift Jr., E. J., & LeValley, B. D. (1992). Microleakage of etched-dentin composite resin restorations. Quintessence International, 23(7), 505–508.

Tanaka, M. (1990). Use of a fluoride-containing sealant on interproximal surfaces. Journal of Dental Research, Abstract 1391.

Telford, A. (1983). Uses of glass ionomer cements in children's dentistry. Dental Outlook, 9, 75.

Thornton, J. B., Retief, D. H., & Bradley, E. L. (1988). Marginal leakage of two glass ionomer cements: Ketac-Fil and Ketac-Silver. American Journal of Dentistry, 1(1), 35–38.

Weerheijm, K. L., de Soet, J. J., van Amerongen, W. E., & de Graaff, J. (1993). The Effect of Glass-Ionomer Cement on Carious Dentine: An in vivo Study. Caries Research, 27(5), 417–423. https://doi.org/10.1159/000261573

Additional References.

Frencken, J. E., Leal, S. C., & Navarro, M. F. (2012). Twenty-five-year atraumatic restorative treatment (ART) approach: a comprehensive overview. Clinical Oral Investigations, 16(5), 1337–1346. https://doi.org/10.1007/s00784-012-0783-4

Hof, M. A., Frencken, J. E., Helderman, W. H. van P., & Holmgren, C. J. (2006). The Atraumatic Restorative Treatment (ART) approach for managing dental caries: a meta-analysis. International Dental Journal, 56(6), 345–351. https://doi.org/10.1111/j.1875-595x.2006.tb00339.x

Mickenautsch, S., & Yengopal, V. (2011). Absence of carious lesions at margins of glass-ionomer cement and amalgam restorations: An update of systematic review evidence. BMC Research Notes, 4. https://doi.org/10.1186/1756-0500-4-58

Ricketts, D., Kidd, E., Innes, N. P. T., & Clarkson, J. E. (2006). Complete or ultraconservative removal of decayed tissue in unfilled teeth. Cochrane Database of Systematic Reviews, 19(3). https://doi.org/10.1002/14651858.cd003808.pub2

Rosenblatt, A., et al. "Silver Diamine Fluoride: A Caries 'Silver-Fluoride Bullet.'" Journal of Dental Research, vol. 88, no. 2, Feb. 2009, pp. 116–125, 10.1177/0022034508329406. Accessed 16 Oct. 2019.

WHO Collaborating Centre for Oral Health Care Planning and Future Scenarios, Radboud University Medical Centre, College of Dental Sciences.

AAPD Policies

Indirect Pulp Treatment (IPT)
  http://www.aapd.org/media/Policies_Guidelines/G_Pulp.pdf

Interim Therapeutic Restoration (ITR)
  http://www.aapd.org/media/Policies_Guidelines/P_ITR.pdf
  http://updates.ihscde.com/presentations/CariesStabilization(Bruce).pdf
  http://www.ihs.gov/doh/documents/ecc/DentalDocs/InterimTherapeuticRestorations.pdf

The Sugar Snack Caries Risk Test

(Dr. Martin L. MacIntyre, BA, DDS, MPH)

Summary

The Sugar Snack Test (SST) measures intra-oral acidity at 5-minute intervals over a 15- minute period after a standardized sugar snack. In a single appointment, SST allows patients to learn how a sugar snack can harm their teeth. They also learn that a change in their behavior can improve the test results and will reduce their risk of developing cavities. SST differs from previous tests in its simplicity, immediacy, adaptability to clinical practice, low-cost and the ease with which clinicians and patients understand its meaning and importance. It can be administered to one person or to a large group. SST has been administered to over 8,000 patients. Its reliability and validity have not been verified using statistical research methods.

"I just wanted to add here that we adopted the Sugar Snack Test in both our Ghana and our Bolivia demonstration projects. Thank you Dr. MacIntyre." – Dr. Steve Duffin

Introduction

Caries is a slowly developing bacterial disease, which not be manifest for months or years after the initial infection. By the time symptoms cause the patient to obtain professional care, irreversible damage has occurred, and tooth vitality be compromised. Early identification of cariogenic risk is essential if the caries process is to be reversed with non-invasive measures (*Carounanidy & Sathyanarayanan, 2009*). The prevention and treatment of dental caries would be greatly enhanced if there were a valid and simple test for caries risk (*Carlos, 1978*) (*Socransky, 1968*) (*Bowen, 1991*).

Background

The relations among plaque acidity, refined carbohydrates and caries were clearly demonstrated by Stephan's seminal research over 70 years ago (*Stephan, 1940*) (*Stephan, 1944*). Snyder, Hardwick, Rapp and others developed tests for oral bacterial acidogenicity, which they felt were statistically correlated with caries risk and activity (*Snyder, 1951*) (*Hardwick, 1960*) (*Rapp, 1963*). These tests had initial popularity but failed to gain long-term acceptance by clinicians for two reasons (*Ellen, 1976*) (*Parkins, 1978*) (*Anders Thylstrup & Ole Fejerskov, 1986*) (*Newbrun, 1983*) (*Nikiforuk, 1985*). First, in the 1950s clinicians didn't feel they needed a test to predict caries since the prevalence was almost 100% and recurrent caries was the norm. In fact, caries progressed so rapidly that it was necessary to take bitewing radiographs every six months to track caries progression. Second, regardless of caries status, the treatment plan was the same: semi-annual exams, oral hygiene instruction, fluoride application, and surgical removal of caries, regardless of the lesion size or depth. This was followed by restoration of the tooth form and function with an inert material (gold, amalgam or tooth-colored plastic composite). Now, 60 years later, the standard treatment is the same, except some dentists are slower to initiate surgical treatment (drill) and remove less tooth structure. Some have added dental sealants to their preventive treatment regimen.

The caries risk/activity tests were also rejected by the research community because statistically, they did not accurately or reliably predict the development of new lesions in individual patients. The focus quickly shifted back to preventive treatments: fluoridation and topical fluoride in the 1950s; fluoride toothpaste in the 1960s; and sealants in the 1970s. These treatments, especially fluoride toothpaste and sealants, led to a hope of eradicating caries. The caries rate went down rapidly in the United States and dental schools began to close, but there was still no full-proof preventive measure or cure for caries.

Since the 1990s, there has been a renewed interest in caries risk assessment in concert with the evidenced-based dentistry movement. Epidemiology studies show that 20% of the population has 60-80% of the caries and researchers now accept either the specific bacterial plaque or the unbalanced biofilm hypotheses of caries causation. There has been renewed hope that it should be possible to predict who will and who won't develop caries. In the 1980s, commercial clinical methods for identifying mutans Streptococcus and Lactobacilli were developed in Europe (*Newbrun, 1983*) (*Nikiforuk, 1985*) (*Loesche, 1984*) (*Krasse, 1985*) (*Ericsson, 1949*). Many studies have demonstrated that bacterial culturing could statistically identify high-risk caries populations but the correlation coefficients were too low to convert this information into meaningful treatment decisions (*Krasse, 1985*). For individual patients, culturing has been even less successful in identifying caries risk or activity because caries is a multi-factorial disease.

Although prediction of caries incidence has been elusive, there remain good reasons for having a simple, fast, reliable, low-cost and accurate caries risk/activity test. The primary reason is to identify the risk before the disease develops. This would allow allocation of preventive treatment resources – more frequent treatments and reassessments for the high-risk patient and, equally important, less for the low-risk patient. This is based on the assumption that on a tooth by tooth basis, preventive treatments and assessments will be more cost-effective and cost-beneficial than a lifetime of restorative treatment. This should be true even when accounting for the wasted cost and time required for risk assessment and preventive treatments for those who might never develop caries. An equally important reason is to be able to determine that treatments have successfully reduced the caries risk factors.

In the 1980s, a unique confluence of factors existed in Saudi Arabia that led the author to develop a caries risk/activity test. There was a population with rapidly rising caries prevalence and incidence despite having at their disposal high-quality, comprehensive dental care and free preventive services. The caries incidence was so high that it outpaced the ability to provide timely restorative treatment before pulp death resulted in tooth extraction and new lesions developed unabated. Caries prediction was unnecessary, but there was still a need to allocate limited resources; to determine if caries control treatments were successful; and to know if patients were following the preventive/control treatment plan. These challenges led to the development of the following: The Sugar Snack Test, a fluoride-sealant caries control treatment (CCT) and a comprehensive caries control regimen. The latter two are described in separate articles.

The medical model for caries causation and treatment has finally been accepted by the research community. However, this approach has barely entered the dental school curriculum, has not been accepted or used by clinicians, and is not reimbursed by the insurance plans. Equally important, it is unknown to patients, just as dental sealants were a virtual secret for over 20 years after they were proven effective. Despite clear reasons for measuring the patient's caries risk and activity there is little professional interest in it. In the light of this perplexing situation, this article presents a new caries risk/activity test in the hope that researchers will want to study it since the author is not in a position to do the research.

Table 1 (refer to page 343) lists characteristics of an ideal caries risk/activity test. The Sugar Snack Test (SST) is designed to have most of these characteristics including the psychological needs of the patient and the clinician.

SST is based on these scientifically proven premises:

- Caries results from prolonged dental plaque acidity (*Stephan, 1940*) (*Stephan, 1944*).
- Bacteria in caries-associated plaque are highly acidogenic (*Ericsson, 1949*) (*Larsen, 1973*).
- Plaque acids come from bacterial metabolism of carbohydrates (*van Houte, Winkler, & Jansen, 1969*) (*Minah & Loesche, 1977*).
- Plaque acidity below pH 5.3 demineralizes dental enamel (*Imfeld, 1983*) (*Edgar, Bibby, Mundorff, & Rowley, 1975*).
- There is a direct correlation between plaque acidity and saliva acidity (*Bibby, Mundorff, Zero, & Almekinder, 1986*) (*Edgar, 1976*) (*Firestone & Muhlemann, 1985*).

SST measures and visually demonstrates the changes in saliva acidity over a fifteen-minute period after a standardized sugar challenge. The results vary according to the quantity and acidogenicity of the oral bacteria counteracted by the quantity and acid buffering capacity of the saliva.

Materials

The SST materials listed in Table 2 are low-cost and widely available. A test form (**Fig. 1**; refer to pages 335-336), with a strip of pH paper attached, is placed before the patient and the other supplies are removed from a cup or plastic bag as needed (**Fig. 2**; refer to pages 337-338). It can be performed anywhere. Before starting, it is essential that the patient and/or parent understand the purpose of the test: to determine if a sugar snack will cause <u>their</u> oral bacteria to produce enough acid to dissolve <u>their</u> tooth surfaces, i.e., cause tooth decay or caries.

Methods

The Sugar Snack Test measures the acidity of pooled saliva using litmus (pH) paper (from pH 7.5 to 4.5). The saliva pH is directly proportional to the plaque pH; with saliva averaging one (1) pH unit higher than plaque (**Fig. 2**; refer to pages 337-338). For the SST, the 7.5 to 4.5 pH scale is converted into a 1 to 5 scale with 1 being the least acidic (pH $\geq$ 7.0), 3 (pH 6.0) and 5 the most acidic (pH $\leq$ 5.0). The 'whole number' scale is easier for the patient to understand than the inverted half-step pH scale. There are three basic scores: above the line (1 or 2 = safe); borderline (3); and below the line (4 or 5 = unsafe).

The SST procedure is summarized in **Table 3** (refer to page 345). It is performed by the patient with coaching from the clinician. Empty the materials on the tissue and follow these steps.

1. **Put a cotton swab into the mouth like a lollipop and soak it with pooled saliva, making it as wet as possible. At the pretest column, keep the swab vertical and press the moistened tip straight down on the acidity test strip (pH paper). Hold for a count of three. Remove the swab, count to ten and compare the color on the paper with the color codes. Mark the result on the graph. Put the swab in a disposable bag.**

The patient should swish their saliva so it passes through the interproximal spaces and picks up the acid. Swishing also pools the saliva from all parts of the mouth.

The pretest measurement represents the patient's baseline saliva pH. It is the first indication of the caries risk level. Most normal individuals will be at SST levels 2 or 3. If the acid level is 1 (pH $\geq$ 7.0), there is a good chance that the final results will be good**.** If the acid level is 5 (pH $\leq$ 5.0), then you might expect the final test results to be poor. False positive or false negative results can occur if, prior to the test, patients have brushed their teeth; chewed gum; or have had an acidic drink or food (lemon).

The <u>resting saliva acidity</u> (pre-test) is the first of a series of seven acidity measurements. While the initial measurement is insufficient to determine risk, it does provide an opportunity to initiate a dialogue in which the clinician can gain the patient's interest and trust. A patient's question might be: "Does this mean the results will be good or bad?" The clinician's questions might be "When did you eat or drink last? What was it?" Did you have a drink of water after that? What about a breath mint or gum? What was in it?

2. **Chew sugar-sweetened, mint-flavored gum for one minute.**

Ask the patient to chew the gum provided on both sides of the mouth to help pool the saliva. Ideally, the series of SSTs should be done at the same time of day and the same number of hours after a standardized meal. However, this is clinically impractical. Instead, the taste, smell and chewing of the initial gum combine to maximize saliva secretion and buffering capacity. Oral acids are diluted and swallowed giving a fresh start, which increases the test's reliability. At the same time, the sugar in the gum initiates a new cycle of acid production in the plaque.

Alternative 1. A sugarless gum can be used instead but be less effective if the sugar substitute has an anti-cariogenic effect e.g., xylitol.

Alternative 2. If the chewing step is also used to obtain a saliva sample for a bacterial culture then you must use the unflavored paraffin supplied by the manufacturer. This avoids adding factors that might affect the culture. Note: For some individuals, unflavored or unsweetened wax will not stimulate saliva secretion and can even have the opposite effect (less saliva). <u>Avoid fruit flavored gum because they usually contain citric acid</u>.

3. **Dispose the gum or wax, soak a second swab, and in the chewing/sweet column wet the pH paper with the end of the swab. Note the color and width; mark the graph below. Connect the first and second marks.**

Most individuals, even some with active caries, will be at level 1, which indicates the saliva stimulation has offset the pretest acidity. A measurement of 3-5 is a strong indication that there be a significant problem, either a high challenge (acidogenic biofilm) or low resistance (low quantity or quality saliva) or both.

Chewing stimulation measures the patient's ability to produce saliva that will dilute and buffer existing acid. The measurement should be 1 (pH >7), the normal acidity of saliva. Again, this is a single reading and does not necessarily indicate that the saliva is sufficient (there can be false readings, which will be discussed later). However, any result more than 1 increases the odds that there be a problem. After each reading, during the 5 minutes before the next measurement, it is important to note if the color changes from the initial reading to a more acidic one. A significant change in the color (safe to borderline or borderline to unsafe) is a measure of the buffering capacity of the saliva (ability or inability to neutralize the acids produced by the biofilm).

In addition to noting and recording the pH of the saliva, this step is used to screen for the saliva secretion rate (SSR). SSR is the volume of saliva in milliliters per minute (ml/min) under standardized conditions (see **Appendix A** for a detailed description; refer to pages 349-351)

Sweet and chewing are two of the major physical stimuli of saliva secretion. Other stimuli are sour (acid), bitter and pleasant food smells. A reduced saliva flow is a prime factor in caries initiation, progression and severity. This is usually the result of long-term medication, drug addiction, head and neck radiation, chemotherapy or underlying pathology e.g., Sjogrens syndrome. Possible causes can be determined by questioning the patient about their medical history and medication usage. Dehydration from low water intake (e.g., following exercise) is a possible, but unlikely, cause.

This portion of the SST provides a simple, preliminary indication of any significant aberration in the saliva secretion rate (SSR). Sometimes the patient has difficulty in wetting the swab and making a mark on the strip while the mark of other patients spreads quickly on the paper. If the saliva mark on the pH paper is smaller than the circumference of the cotton swab end, then this is an initial indication that the secretion level could be low. <u>Don’t draw an immediate conclusion or let the patient sense your concern</u>. Just make a mental note to compare this mark with the remaining five marks that are the result of different stimuli or lack thereof. If the mark sizes continue to be small or they don’t increase after stimulation, then further tests and questions are needed to confirm a low secretion rate, and to determine the extent and cause. Being nervous can lower saliva secretion just like nervousness can raise blood pressure.

4. **Suck on a sugar snack (mint) for two minutes.**

Caution the patients must not bite the mint, which will wedge particles of mint between the teeth and into fissures. Ask the patient to move the mint around their mouth so all the acid-producing bacteria will have “a maximum opportunity to eat the sugar and to deposit harmful acids on your teeth.” Use the same size and flavor mint for all patients. <u>Avoid fruit flavors,</u> which usually contain citric acid.

5. **Remove all undissolved mint, re-measure, and mark the acid level under the “sweet” column.**

Most patients, even a few high-risk patients, remain at level 1 because newly produced acid is still within the plaque or is neutralized by the saliva’s buffering capacity, which is at its highest level after chewing and sucking on something sweet. However, most high-risk patients will start to show an increase in saliva acidity. Level 2 is still “above the line” but indicates that enough acid has been produced to lower the pH to 6.5. A few patients drop down immediately to level 5, which is pH 4.5 or less. Try not to gasp, frown, smile or otherwise suggest your evaluation of the meaning of each measurement. Whenever possible, let the patient's questions direct the discussion and let the patient perform the test procedures so they will understand and accept the results. The patient-centered approach will make the test more personal, will help them explain it to family members who aren't present and will train them to perform the self-test at home.

Compare the colors of the first three readings (pre-test, chewing and sweet). If there has been a marked color change in the direction of increased acidity, then it might indicate a low buffering capacity. Even if the pH of saliva stimulated by chewing is SST-1, the buffering capacity of the saliva could be low. A low buffering capacity means that the natural buffers are lacking in the saliva. The proportion of these buffering compounds is normally increased when the saliva flow rate is increased. Buffering capacity is a characteristic of the saliva and is therefore not directly affected by elimination of the acid-producing bacteria. Comparison of the changes over time in the first three readings can give additional clues vis á vis buffering capacity.

There is a commercial buffering capacity test in which a standard amount of saliva is combined with a standard amount of acid for a standard amount of time in the presence of litmus paper. This test can be used if the SST indicates buffering capacity be a significant part of the problem. There is no specific treatment that will increase the buffering capacity other than increasing the salivary flow rate. However, it is important to know that this risk is present in making an accurate diagnosis and correctly interpreting the test result. There can be a false low buffering capacity test result if the saliva is already acidic from the bacterial acids. In these cases, a major improvement in the buffering capacity following a treatment regimen is a strong indicator of success and you can expect to find similar improvements in other risk factors.

6. **The next three measurements (A, B & C) are taken at 5-minute intervals. They are marked on the form and connected to show any change.**

These are the three key measurements since they are the direct result of interactions among the retained sugar, the bacteria and the saliva. The first three measurements were affected by unknown factors (pretest) or were artificially stimulated (chewing and sweet). The factors that contribute to each result are discussed with the patient between measurements. Each test and each measurement is a learning experience for the patient and the clinician (about the test and about each other). It is possible to make fairly accurate estimates of what the next measurement might be based on the preceding ones. However, until the clinician has used the test at least 200 times, this temptation should be avoided because there are unexpected exceptions that require a high level of understanding and relatively complex explanations. As the test results unfold, the suspense keeps the focus of attention on the next measurement and its implication (thumbs up or thumbs down). The discussion can easily occupy the five- minute interval between measurements. The time can also be used to perform additional tests on the saliva and complete the patient interview.

DO NOT USE A WATER SYRINGE OR ALLOW THE PATIENT TO RINSE OR DRINK DURING THE TEST.

7. **Chew sugarless gum for one minute and make a final measurement.**

The chewing and sweet taste both re-stimulate the saliva without adding sugar. Again, do not use fruit flavors. All patients should have their pH go up. Almost all will be at or above level 3 ("above the line") and a majority will be at levels 2 or 1. This is a hopeful sign and the patient will correctly conclude that chewing sugarless gum produces a quick reduction in acidity. This measurement can convert a prior level 5 to become level 1!

8. **The test is scored, analyzed, copied and then given to the patient.**

Patients who go below the line will invariably ask what they can do to improve the results. This is the teaching moment for which the clinician must patiently wait. A question means the patient wants to know. If the patient's desire to know is lacking, the information that is given will be wasted.

For reasons of infection control, before the test is performed an adhesive tape is place on the opposite side of the test form, underneath where the pH strip is located. This keeps any saliva from leaking through the paper. Following the test, the pH strip is covered with transparent adhesive tape, before the completed test is photocopied.

Results

With seven measurements at five possible levels of acidity, there are over 5000 permutations of which at least 2500 are legitimate possibilities. The variation is great. Among the thousands of tests that have been performed, there have been three patients with the highest possible score (all "1s"), two with the lowest possible score (all "5s") and no patients with all 2s or all 3s or all 4s. There have been only a few with identical results or "curves" with the normal curve being similar to the one for saliva in **Fig. 2** (refer to pages 337-338). A patient with a high caries risk might have a curve with a similar shape but at the level of the one labeled plaque in **Fig. 2** (refer to pages 337-338). The fifteen minutes following the sugar snack is the crucial period, labeled A, B & C. If the last step, sugarless gum, were not performed, then the acidity could remain in the "unsafe" zone for up to two hours and even longer.

The three measurements are averaged and rounded off to produce a single number between one and five. This makes it easier to discuss the results with the patient and to compare test results for a series of tests. An even easier, more accurate method and the most meaningful to the patient, is a direct visual comparison of the amount of area of the curve that is below the borderline. This is what most patients do without being told. If there is more than one patient, they will naturally peek at the others' tests to see how they compare. The variations can be extreme and instigate further useful discussion. Patients can improve greatly from one test to the next if they follow the treatment regimen. Those who do not improve will usually admit to not following the treatment plan.

The result of each step provides clues to the factors contributing to the patient's caries risk and suggests what treatment might be successful. There are many nuances in the test that can't be detailed in this article. Each test provides the clinician with added insight into the patient and the test results. In assessing caries activity and in developing a treatment plan for caries control, the SST 'curve' is just one of many test results to be considered. Other tests, including bacterial culturing, buffering capacity, and saliva secretion rate, provide more specific information that helps in the development of a treatment plan.

Monitoring Treatment - a Case Report

Figures 3-6 (refer to pages 339-342) are the Sugar Snack Test results for a 44-year-old patient with a cleft palate. They were obtained at four separate appointments over a 14-week period. The patient was referred by her prosthodontist after completing the restorative treatment but prior to preparing a new obturator. The reasons for the referral were the patient's "extremely poor oral hygiene and continuing caries activity". The test results and interim treatments are summarized in **Table 4** (refer to page 346).

The treatments that preceded each test are highlighted at the bottom of each test form. The SST results, other risk factors (saliva secretion rate (SSR), buffering capacity (BC), mutan Streptococcus (SM), and Lactobacilli (LB)) are in the diagnosis section (Dx) and treatments (oral hygiene instruction OHI, fluoride and chlorhexidine will be discussed as they enter the picture. The same 1-5 risk scale (low to high) is used for all tests except for caries rates (dDT and DMFS).

The baseline results, (**Fig. 3**; refer to page 339) show that despite years of the best available treatment from caring clinicians, the caries risk continued to be extremely high. At a consultation appointment following the first battery of tests a treatment plan was recommended:

- Rx: Chlorhexidine 0.2 % w/v q.i.d. p.c. & h.s.
- Brushing and flossing t.i.d. p.c. with a fluoride dentifrice 1500 ppm
- Diet control

The patient strongly objected to the chlorhexidine because of potential staining. She said she knew that her problem was poor brushing technique. The patient's self-diagnosis was consistent with her guilt from ignoring years of oral hygiene instruction from a myriad of dental hygienists and dentists. At this point there was complete disagreement on the diagnosis and major disagreement on the treatment plan. The only real agreement was on the SST results. The patient was apathetic and seemed resigned to her "problem". To maintain her interest, the treatment plan was modified to match her perception of the problem. It was mutually agreed that if the problem were only ineffective brushing, then the test results would dramatically improve with improved brushing.

Five weeks later, the patient's oral hygiene had improved dramatically (from a 5 to a 2) and there was a slight improvement in the STT results, **Fig. 4** (refer to page 340). The patient was pleased that there was improvement in the SST because it supported her diagnosis (poor brushing). Although pleased, she could see that she was still "way below the line." The saliva secretion rate also improved from a "3" to a "1". The saliva secretion was probably depressed at the first "tense" visit and returned to normal at the second "more relaxed" visit. The slight improvement in the SST was more likely due to the increased saliva secretion than to improved oral hygiene. Regardless of the relative importance of these factors, the average SST score was still a dismal "5".

The patient asked if there were a non-staining treatment. The only choice was high concentration (5,000 ppm) fluoride gel for use at home. For this purpose, fluoride trays were made from existing study models. As shown in **Fig. 5** (refer to page 341), at week 10 this treatment produced further improvement in the SST and a reduction in the SM count. Note that the improvements were despite a reversal in the oral hygiene score. This reversal was not commented on by either the clinician (to avoid saying "I told you so") or by the patient (to avoid admitting to a relapse in her oral hygiene). The improvement was undoubtedly due to the 1% neutral sodium fluoride, which is bactericidal for mutans Streptococci and caused the SM score to go from 5 to 3 and the SST score improving to 4. For the patient and the clinician these were major signs of hope. The patient now had hope of getting "above the line" and the clinician now felt that the patient might eventually accept the original treatment plan. A common trust in the SST results was especially important. The testing process was bringing the patient and clinician into closer agreement on the diagnosis and the treatment plan. The test results graphically indicated both improvement as well as unfinished business. The patient's original apathy was gone and now she really wanted to succeed, which meant getting "above the line." The patient now suggested trying chlorhexidine to reduce the SM count. She knew that this was the most effective method from discussions that took place during the intervals between measurements and she could see that reduction in the SM count was very effective in improving the SST results. Mindful of the patient's initial objections to chlorhexidine, the clinician suggested combining the chlorhexidine with the fluoride in order to keep what already had been successful and to mask the bitter taste of the chlorhexidine. A prophylaxis was scheduled to remove any stain from the chlorhexidine.

Fig. 6 (refer to page 342) and **Table 4** (refer to page 346) show the raw scores but don't show the tension that was felt as the test progressed. At this test, each measurement was awaited with fear, hope and trepidation. When the first two results were excellent the hopes were high. Doubts quickly returned when the reading fell one point at the "A" reading and down to the borderline at the "B" reading. They (the patient and clinician) felt they were on the verge of falling into an abyss even though the result was already better than the previous appointment. Better was no longer good enough. Now both would be disappointed with anything below the line. Would the "C" reading go below the line? To the bottom? or would she get the gold medal? The moment that the "C" measurement was taken and the color was green, "on the line", both patient and practitioner literally cheered in a combination of joy and relief.

The results of the other caries risk measurements: buffering capacity, mutans Streptococcus and plaque score showed changes consistent with the improved SST score and the use of chlorhexidine. The Lactobacilli count is unaffected by chlorhexidine and therefore remained high. Since there were no visible or radiographic signs of caries to explain the high lactobacilli count, a snacking habit was the only explanation, a habit the patient had revealed during discussions. The snacking pattern has been a life-long pacifier related to her cleft palate and associated insecurities. A direct attack on the snacking pattern had been purposely by-passed until the patient was ready to tackle this, the most difficult behavior modification. A drastic and prolonged reduction in snacking would reduce the lactobacilli counts and was the only method left to significantly improve the SST result. A reduction in snacking would also allow a tapering off, and possibly the elimination of the high concentration chlorhexidine and fluoride treatments. Unfortunately, the patient moved away before diet control could be attempted. Although the results were gratifying, the prognosis was still guarded because a lifetime cariogenic dietary habit is extremely difficult to reverse on a long-term basis.

Discussion

In the 1940s Stephan first demonstrated the graphic curve of oral plaque acidity that follows a sugar challenge (*Stephan, 1940*) (*Stephan, 1944*). He showed that the curves varied directly in relation with the level of caries activity. Patients with greater caries severity had a deeper curve representing more acidity. SST is a very simple, basic test using saliva instead of oral plaque. All the necessary materials and knowledge were available in 1940.

In 1950 Snyder developed an in vitro test that measured the oral bacteria acid production of the patient's saliva (*Snyder, 1951*). Snyder's test and similar tests were widely evaluated but correlated poorly with the development of new lesions (prediction). The test results took days to unfold and required a follow-up consultation appointment.

In 1952, Hardwick developed an in vivo test using methyl red dye to indicate areas of high acid production on the teeth after an intra-oral sugar challenge. In 1960 he thought he demonstrated that it was reasonably predictive of caries and caries risk (*Hardwick, 1960*). The results were available at the same appointment and identified individual teeth and surfaces at high risk. It appeared to be an ideal test. A repeat of the study in the United States failed to corroborate Hardwick's results. An interview of one of the examiners and study authors revealed that the U.S. study had major flaws, which were not acknowledged in the published article (*Greene, 1998*).

For a time, these and many similar tests were used as caries screening and educational tools in prevention programs. They never gained widespread use in clinical practice and eventually were discontinued. They were viewed by clinicians as too scientific, impracticable and unpredictable. The major problem was the lack of treatment regimens that could significantly improve the test results in the short-term.

The research community criticized these tests for failing to accurately and reliably predict which patients would develop new lesions (*Socransky, 1968*). However, the multiple-factorial nature of the caries process, its slow progression and frequent reversals makes it unlikely that a valid, accurate and reliable caries-prediction test will ever be developed. By expecting an ideal test (**Table 1**; refer to page 343) the tests were doomed to failure.

In the 1980s and 1990s, interest in caries risk/activity tests re-emerged with the acceptance that caries was a specific bacterial infection (or now a dysfunctional biofilm) and that initial lesions could be reversed by safe, effective non-invasive measures. Most of the newer tests attempt to count the number of salivary mutans Streptococci and Lactobacilli.[14,15] It was thought that this would finally permit the prediction of new lesions but the correlation coefficients for individual patients are low. Cultures and other socio-economic factors are still being studied as predictors of caries in specific populations, but past caries experience remains the best predictor of future caries experience for an individual patient and even this falls far short. Past caries as a predictor won't help if you are interested in primary prevention and it won't help you to know if treatment or circumstances have changed the risk level or the caries activity.

Imfeld developed a method for an in vivo measurement of the pH at a specific inter-proximal tooth site as a means of identifying which dietary items were potentially cariogenic. Although extremely accurate and reliable, it wasn't intended for use in the dental office for diagnosing a patient's caries-risk (*Imfeld, 1983*) (*T. N. Imfeld, 1983*).

A less ambitious and realistic goal is to assess caries-risk based on factors associated with caries. Equally important is the monitoring of treatment results without waiting to see if a carious lesion does or doesn't develop. SST is this type of test. It is a more simple form of the Snyder test; it includes two important elements of Hardwick's test -- a sugar challenge and immediate results; and it has one characteristic of Imfeld' s method -- the ability to observe the acidogenic process over a period of time following a sugar snack. This last characteristic is equivalent to the difference between a snapshot (most tests) and a video (SST).

SST replicates the acid level in a patient's mouth when a sugar snack is consumed. The patient can see what their mouth is like before they start the test and then the effect on their oral acidity for each succeeding factor: chewing, sweet, sugar, and time. Most importantly, they can see what happens during the 15-minute period after they have a sugar snack and the effect of bacteria and saliva on the results. The objective is to determine how long the <u>plaque</u> acidity is at a level that can demineralize the enamel. Acidity of the plaque is measured indirectly by measuring the acidity of <u>pooled saliva</u>. Many studies have shown that the acidity of plaque is at least one acid (pH) unit lower than pooled saliva (*Bibby, Mundorff, Zero, & Almekinder, 1986*). If the saliva acidity is SST-3, the plaque acidity is definitely SST-4, and could be more. Tooth enamel demineralizes at SST-4 (pH 5.5). The SST measures the acidity of a saliva sample that has received acid from the pooled plaque. This acid could come from one large cavity filled with many acidogenic bacteria, from many initial lesions, or from acidogenic plaque not associated with visible lesions. Also, acidogenic bacteria that do not cause live in the crevices on the tongue and the tonsils. The saliva should be pooled to obtain an accurate and reliable result. The longer the acid level is 4 or 5, the greater the risk. The causes of the acidity may be one or more of the following: high numbers of acidogenic bacteria, virulent bacteria that produce a great deal of acid, low buffering capacity of the saliva and/or a low saliva secretion rate. Patients who are at SST 2 or 3 for ten minutes and then drop below the line have resistance factors that, for a limited time, have been effective, but ultimately are depleted. If the acid test paper initially has islands of darker color, it is most likely due to variations in the viscosity of the saliva with the darker color representing saliva that has not "pooled" with the other saliva. The lighter color is used as the correct reading and the patient is asked to swish the saliva before providing the next sample. If lighter "islands" develop as time progresses, they reflect patches of bacteria that continue to produce acid.

The saliva test usually shows a good SST result in the first 5-minute period as a result of increased saliva flow in reaction to the sweet taste. Studies of normal individuals have shown that immediately after sugar intake, the saliva acidity is at its highest pH (least acid) and plaque is at its lowest pH (most acid). During the next 15 minutes, after the sugar (sweet stimulus) is removed, the positive effect of saliva begins to diminish while the amount of plaque acid production begins to be manifest. If the acidity is more than SST- 4 or 5, demineralization be taking place on a general basis, but it is more likely that there is significant demineralization taking place at one or more specific locations and no demineralization on the remainder of the tooth surfaces. One can postulate that the lower the acid reading and the faster it reaches that point, the greater the number of demineralization sites, the more virulent the bacteria, and the lower the buffering capacity.

Again, it is worth remembering that the direction of the previous readings, towards a lower or higher acid measurement after the initial measurement would indicate the saliva's buffering capacity.

SST is particularly effective as patient education, since it clearly demonstrates:

1. The oral cavity is a dynamic organ which reacts to outside elements (sugar snack);

2. The oral cavity has weaknesses and strengths that the patient or parents can't see or feel; and

3. That both 1 and 2 can be controlled.

SST replicates the type of habit (sugar snack) that is very difficult to change, exactly what the clinician will be asking the patient to do. In addition, SST is able to demonstrate to the patient in real time what happens in their mouth based on the close relation between plaque acidity and salivary acidity (**Fig. 2**; refer to pages 337-338). It does not identify specific carious sites and therefore can have false positives. However, standard caries diagnostic methods all have a significant degree of false positives. No test is infallible and none can be relied on exclusively. False positives with SST are related to acid production from non-cariogenic bacteria, from bacteria on non-tooth locations, or because the patient is not feeding frequently, i.e., not replicating the test. These factors can be accounted for by carefully questioning the patients about their dental caries experience.

There can also be false negative results, for example, when the SST score is in the SAFE range but there is one or more active carious lesions. In these instances, the acid produced from this lesion is not sufficient to raise the pH of the pooled saliva or to overcome the buffering capacity of the saliva. Of course, there is the possibility that this isn't a false negative because the lesion(s) could be in remission and not producing acid. If this were the case, then the result would be a true negative i.e., cavitation but no caries risk or activity. The test format reduces the potential for both false positives and false negatives by having three measurements over a fifteen-minute period; the equivalent of three separate tests, which reduces the chance of a completely false positive or false negative test results.

There is little harm from a false positive result and something to be gained. Patients do not want to be below the line; even once. A false positive result motivates the patient to improve their anti-caries activities without the need for admonitions from the clinician. False negative results are very rare and will be uncovered by a thorough examination and the patient's dental history. As mentioned before, the presence of a cavitation does not necessarily mean the caries process is active; it could be arrested.

The strength of SST is in its immediate results and face validity. When the pooled saliva sample has a pH below the level at which enamel demineralizes, then enamel demineralization is taking place and will continue for some time unless there is intervention. When the appropriate intervention occurs, such as increased saliva secretion or increased buffering capacity from chewing sugarless gum, or reduced SM count from chlorhexidine, then the test results will improve.

SST is not meant to be a substitute for an examination or as a method of predicting new lesions. Rather, it is meant to alert the patient and clinician to the risk of undetected lesion or simply the potential for caries i.e., an estimate of the risk for developing new lesions or having existing ones that progress. The results are also important in selecting an individualized caries control regimen and to evaluate its effectiveness of the treatment or the lack of the patient's cooperation.

Even if SST is proven to be accurate, reliable and successful in identifying caries risk, it could still be ineffective if dentists aren't compensated for using it. This will depend on whether insurance companies decide that SST will lower their costs by preventing more costly procedures, by either preventing caries or by providing a test threshold that patients must passed before expensive procedures will be authorized. It could even be used as a method for determining insurance rates e.g., "the better the test results the lower the rates".

The Sugar Snack Test has been used in the operatory, classroom and homes. It can be used with individuals as young as age three and for entire families. Visual cues and maximum patient involvement make it useful in multilingual settings where communication of complex concepts is difficult.

Summary

The Sugar Snack Test for caries risk and activity has been developed to manage high- risk caries patients and to eliminated unnecessary diagnostic and treatment regimens for low risk patients. The major advantages are: 1) immediate results for use in treatment planning and monitoring, 2) patient acceptance, 3) patient involvement, 4) simplicity, and 5) low cost. In easily understood terms, the test demonstrates to the patient that sugar snacks, bacteria and saliva are factors in tooth decay and that by controlling these factors the patient can control tooth decay. This realization is essential for successful completion of a caries control treatment plan.

When the result of the SST is combined with results from other caries risk tests, there is enough information to design an individualized caries control regimen. The Sugar Snack Test was developed to assess the effectiveness of treatment in high-risk patients who frequently do not follow through on the treatment plan. Clinical experience has shown that high-risk patients have dramatic short-term improvement in the SST when the caries control regimen is followed. The SST does not improve if the patient does not follow an individualized treatment regimen based on an analysis of the test results.

A new study of Hardwick's 'methyl red' test seems warranted now that the caries rate is relatively low because prediction of new lesions is no longer the primary goal, and remineralization of early lesions is an accepted treatment, in both theory and practice. If SST and Hardwick's tests both prove successful, they could be combined into a single appointment to locate specific sites of acidogenic activity while educating and motivating the patient.

SST is scientifically based, instructive, motivational and enjoyable. It has a high face-validity for both the patient and the clinician. The inexpensive and widely available materials allow its use in varied settings (both individuals and groups, clinics and classrooms). Evaluation of SST using accepted research methods (random sampling and control groups) has not been performed. This article is intended to provide researchers and clinicians with the means for preliminary trials using a copy of the test form, **Fig. 1** (refer to pages 335-336).

The Sugar Snack Test evolved over a 13-year period of clinical use in a multinational group practice. Over 4,000 patients and 8,000 tests have been performed and individually analyzed. SST is used as a central element in a system of caries risk assessment and control. SST is repeated during the course of treatment to determine patient compliance and treatment success/failure (**Fig. 3-6**; refer to pages 339-342). The results have been consistent with patient performance and with other caries risk/activity tests (caries- associated bacteria and buffering capacity). SST has been used in the operatory, classroom and self-administered in patients' homes. It can be used with individuals as young as age three. Visual cues and maximum patient involvement make it useful in multilingual settings where complex communication may be limited.

Conclusion

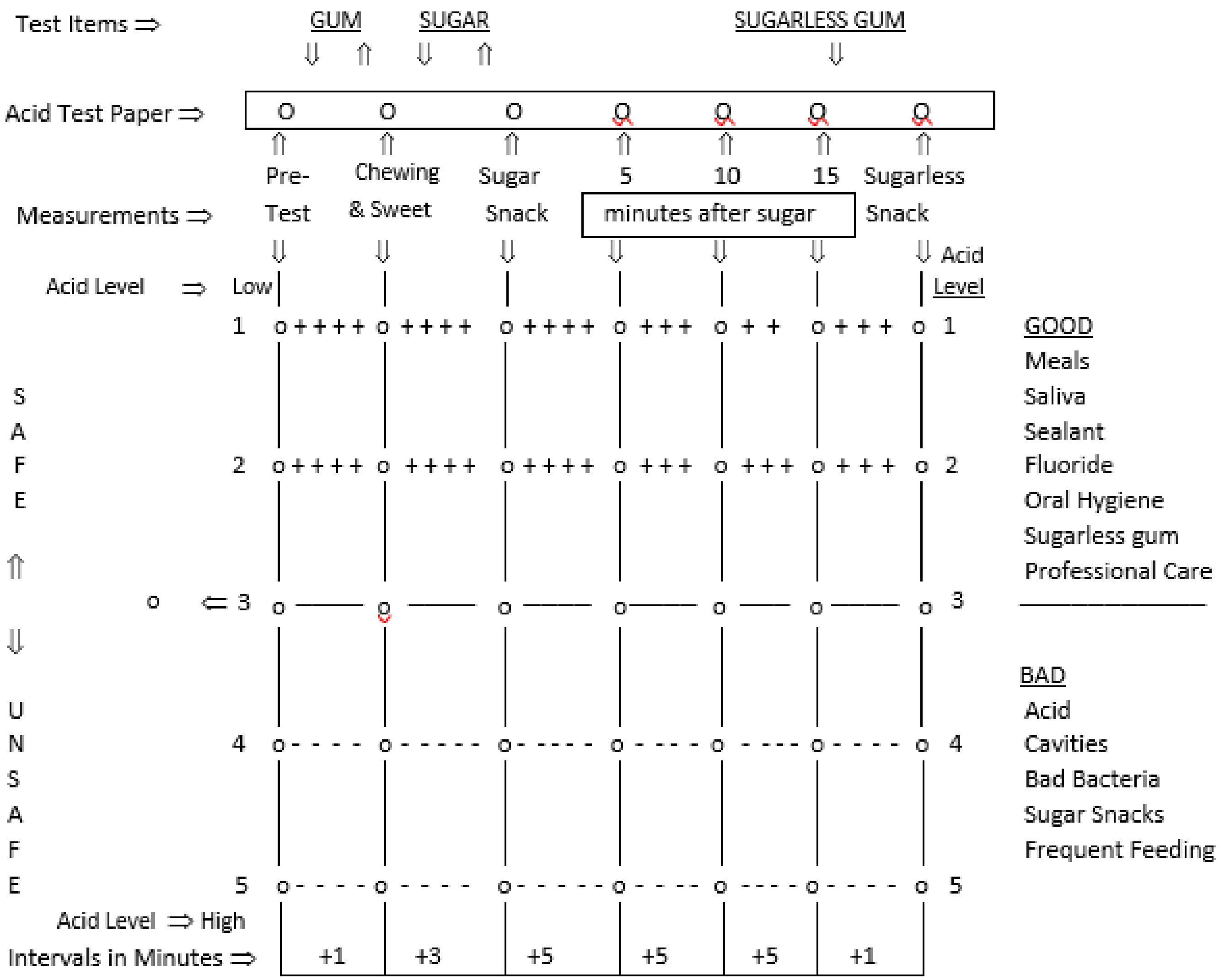
A simple, low cost, diagnostic, educational, motivational and adaptable caries risk assessment test has been described. It is consistent with the scientific literature on caries causation and fulfills many of the requirements for a successful caries risk test. It produces immediate patient interest and acceptance and the test results improve when the patient follows current treatment regimens. SST addresses many of the problems that have kept other tests from widespread clinical use. It has not been demonstrated that clinicians want this type of test. However, this would change if dental treatment were evidence-based and subject to cost-benefit or cost-effectiveness analysis. The Sugar Snack Test needs to be studied under carefully controlled research conditions.

If you have any questions about this section, you can contact me directly using the email listed below.

martin.macintyre@juno.com

Figure 1: Sugar snack test form.

PATIENT'S NAME ____ Yr ____ - Mn ____ - Dy ____ Hr ____ A P CLINICIAN ____________ DATA # ____________



Minutes After Sugar Snack ⇒ 5 10 15

Sugar Snack Scoring ⇒ ___ + ___ + ___ = ___/ 3 = ____

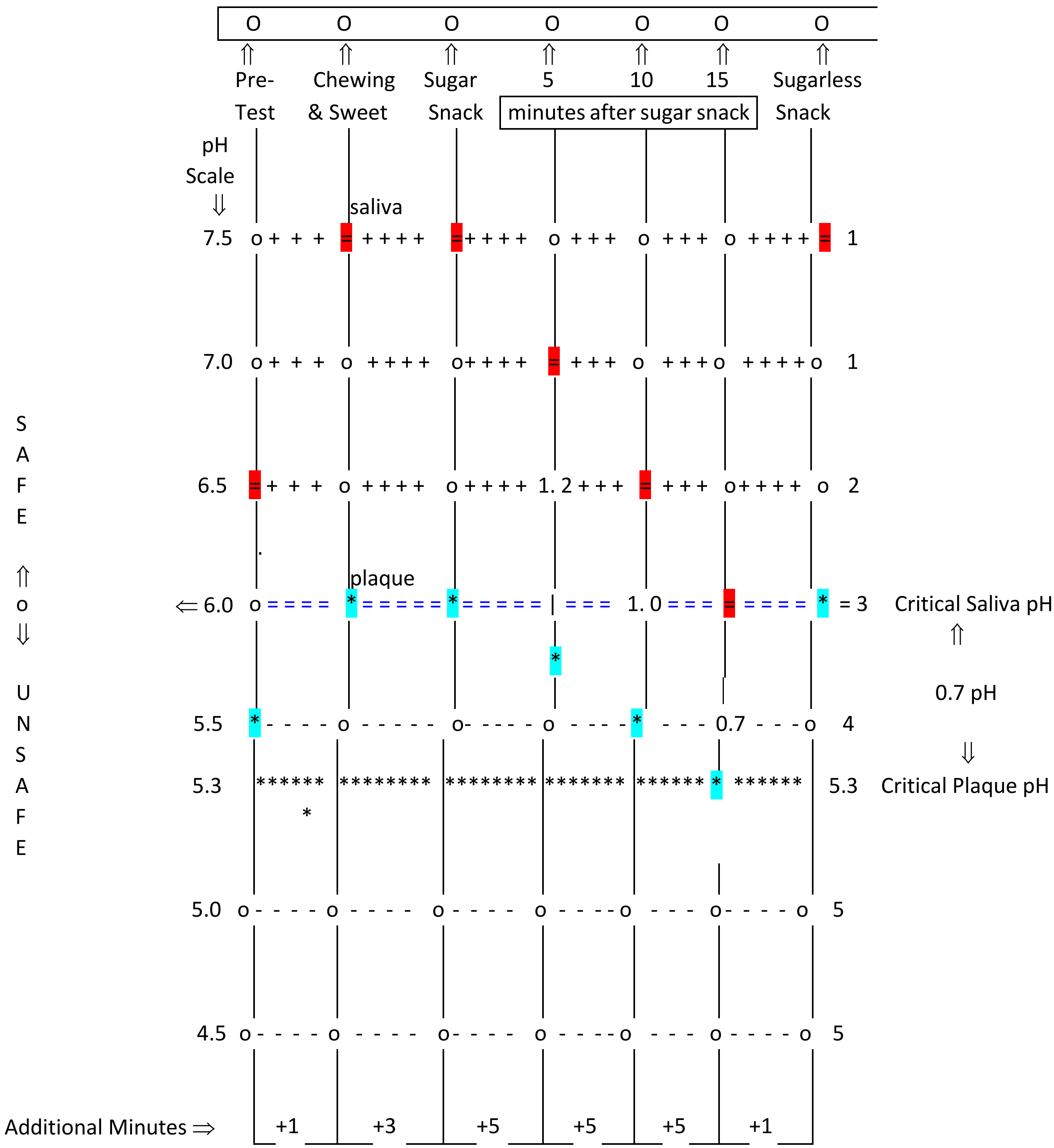
Score Meaning ⇒ 1 - Very Safe 2 - Safe 3 - Borderline 4 - Unsafe 5 - Very Unsafe

MAJOR RISK FACTORS					OTHER RISK FACTORS					
Dx:	____	____	____	__________	_____	____	_____	____	____	______
	SSR	BC	SST	SM+LB/2	SM	LB	DIET	OH	dDT	DMFS

SSR - Saliva Secretion Rate
BC - Buffering Capacity
SST - Sugar Snack Test
dDt - Primary and Permanent Decayed Teeth
DMFS - Decayed, Missing & Filled Permanent Surfaces
SM - Streptococcus mutans
LB - Lactobacilli

Tx:				
	Dental Health Education	Diet Counseling	Fluoride Agent	Saliva Tests
	Oral Hygiene Instruction	Sugar Substitute	Bis-GMA Sealant	Antacid
	Glass Ionomer Sealant	Sugarless Gum	Antibacterial Agent	__________

Figure 2: These are the relations between the hydrogen ion concentrations of plaque and saliva in the Sugar Snack Test. The pH scale is on the left and the test's acidity scale is on the right.



(PLAQUE shown as ********) (SALIVA shown as ========)

The minimum critical pH for plaque is 5.3 and the equivalent minimum for saliva is pH 6.0 or 3 on the SST acidity scale. Below these points the enamel will demineralize. The difference between plaque pH and saliva pH varies depending on the stage in the test. During the three stages following the sugar snack, the average difference ranges from 1.2 pH units at 5 minutes to 0.7 pH unit at 15 minutes. The minimum difference of 0.7 pH units is used for the critical three measurements after the sugar snack thus making a straight line that is easier for the patient to understand. If the saliva pH is below 6.0 (3 on the SST scale), the plaque pH will be below 5.3 at each of the three testing times. This example represents the mode for a “normal” patient without active caries.

Figure 3.

Patient I.D.# __1436____ Date __3_ - _22_ - *1987* Clinician # _2___
mn dy yr

Tx # __1___

	Pre-test	Chewing & Sweet	Sugar Snack	A 5 min.	B 10 min.	C 15 min	Sugarless Snack
	⇓	⇓	⇓	⇓	⇓	⇓	⇓
1	O	O	O	O	O	O	O
2	O	O	O	O	O	O	O
3	O	O	O	O	O	O	O
4	O	O	O	O	O	O	O
5	O	O	O	O	O	O	O
				5 ⇓	10 ⇓	15 ⇓	
				_4__	_5__	_5_ ⇒	____5__ ST Avg.l

Dx: _3__ SSR _*4*_ BC _5_ ST _5_ SM _5_ Lb _0_ dt __53_ DMFS

Tx: OHI _*X*_ NaF ___% APF ___% CHX ___% CaCO3 __ dt __ DMFS ___

Sealants CCT Sugarless Gum Sugar Substitute Diet Counseling

Figure 4.

Patient I.D.# ___1436___ Date _4__ - _29__ - _87_ Clinician # _2__
mn dy yr

Tx # ___2___

	Pre-test	Chewing & Sweet	Sugar Snack	A 5 min.	B 10 min.	C 15 min	Sugarless Snack
	⇓	⇓	⇓	⇓	⇓	⇓	⇓
1	O	O	O	O	O	O	O
2	O	O	O	O	O	O	O
3	-------O	---------------O	-------------O	---------------O	--------------O	--------------O	------------O
4	O	O	O	O	O	O	O
5	O	O	O	O	O	O	O
				5	10	15	
				⇓	⇓	⇓	
				_4_	_5_	_5_ ⇒	___5___ ST Avg.

Dx:	_1__	_4_	_5_	_5_	_5_	_0_	__53_
	SSR	BC	ST	SM	Lb	dt	DMFS

Tx: OHI _X_ NaF _1_% APF ___% CHX ___% CaCO3 ___ dt ___ DMFS ___

Sealants CCT Sugarless Gum Sugar Substitute Diet Counseling

Figure 5.

Patient I.D.# ___1436__ Date __6_ - _14_ - _87___ Clinician # __2__
mn dy yr

Tx # ___3__

	Pre-test	Chewing & Sweet	Sugar Snack	A 5 min.	B 10 min.	C 15 min	Sugarless Snack
	⇓	⇓	⇓	⇓	⇓	⇓	⇓
1	O	O	O	O	O	O	O
2	O	O	O	O	O	O	O
3--------	-O---------------	-O------------	-O-------------	-O--------------	-O--------------	-O-----------	-O
4	O	O	O	O	O	O	O
5	O	O	O	O	O	O	O
				5	10	15	
				⇓	⇓	⇓	
				_3_	_4_	_5_ ⇒	___4___ ST Avg.l

Dx:	__1_	_4_	_4_	_3_	_5_	_0_	__53_
	SSR	BC	ST	SM	Lb	dt	DMFS

Tx: OHI _X_ NaF _0.2_% APF __% CHX _0.2_% CaCO3 __ dt __ DMFS ___

Sealants CCT Sugarless Gum Sugar Substitute Diet Counseling

Figure 6.

Patient I.D.# ___1436__ Date __7_ - _11_ - _87_ Clinician # __2__
mn dy yr

Tx # __4___

	Pre-test	Chewing & Sweet	Sugar Snack	A 5 min.	B 10 min.	C 15 min	Sugarless Snack
	⇓	⇓	⇓	⇓	⇓	⇓	⇓
1	O	O	O	O	O	O	O
2	O	O	O	O	O	O	O
3	O	O	O	O	O	O	O
4	O	O	O	O	O	O	O
5	O	O	O	O	O	O	O
				5 ⇓	10 ⇓	15 ⇓	
				_2_	_3_	_3_	⇒ ___3__ ST Avg.

Dx: _1_ SSR _3__ BC _3_ ST __1__ SM _5_ Lb _0__ dt _53__ DMFS

Tx: OHI _X_ NaF *0.2*_% APF ___% CHX _0.2_% CaCO3 __ dt __ DMFS ___

Sealants CCT Sugarless Gum Sugar Substitute Diet Counseling

measures caries risk	accurate	safe	enjoyable	user friendly
measures caries activity	reliable	cheap	ecological	long shelf life
measures caries intensity	face validity	valid	educational	self-application
measures treatment effect	immediate result	simple	motivational	low technology
locates site of future caries	predicts caries			

Table 1: Characteristics of an ideal caries test.

RECOMMENDED	SUBSTITUES
pH paper: minimum pH range 5.0 to 7.0 five color scale *	none
sucrose (non-fruit flavored candy mint) *	none
7 cotton swabs *	dry, clean fingertip
sugar & sugarless gum (no fruit flavor) *	paraffin (flavored or unflavored)
alarm timer	watch or clock
test form (Fig. 1) *	hand drawn form
felt tip pen (washable)	pencil
transparent adhesive tape	
facial tissue	paper towel or tray cover
* essential materials	

Table 2: Test materials.

STEP	ACTIVITY	MEASUREMENT OR PURPOSE	STEP	MIN./ STEP	CUM. MIN.
1*	Soak cotton swab with saliva	Pre-test pooled saliva pH	1	<1	0
2	Chew sugar gum, sugarless gum or unflavored paraffin	Removes pre-test acid, max. stimulation of saliva and begins feeding bacteria.	2	<1	1
3	Soak swab	Max. stimulated saliva pH	3	<1	1
4	Suck on sugar mint	Feed acidogenic bacteria	4	1	2
5	Remove mint and soak swab	Saliva pH stimulated by sweet & sugar + acid from bacteria	5	<1	3
6	Soak swabs x 3	Saliva pH q.5 min. after sugar snack	6	15	18
7	Chew sugarless gum	Saliva pH stimulated by sweet & chewing without sugar	7	1	19
8	Score test, analyze results, plan treatment	Patient education, motivation, treatment	8	1-5	20-24

* the test form is marked after each step

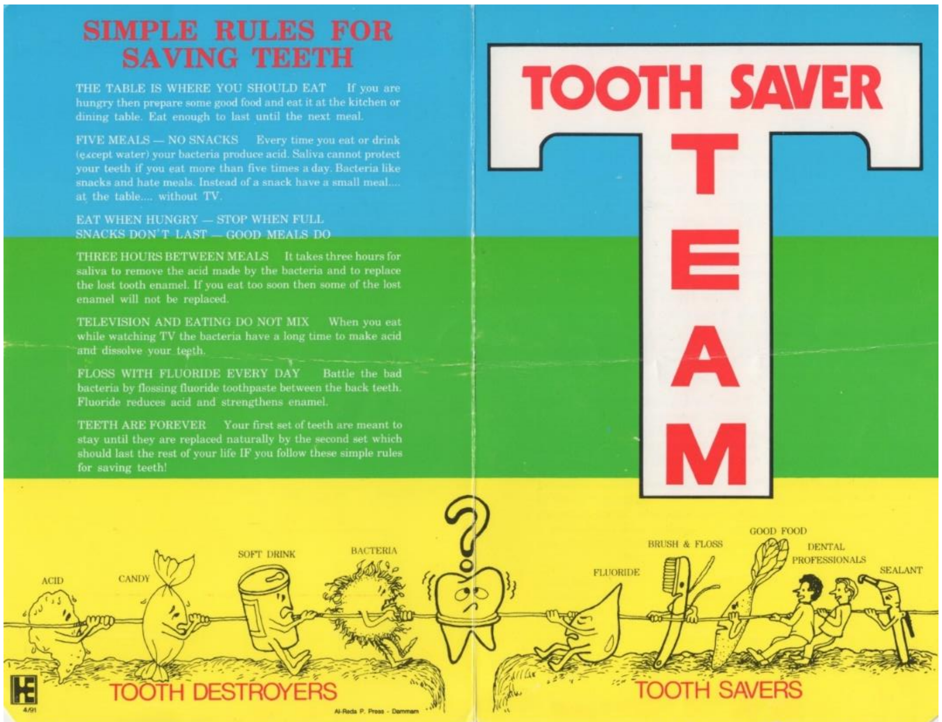
Table 3: Procedure summary for the sugar snack test.

CARIES ACTIVITY/RISK MEASUREMENTS	TEST RESULTS * 0 Weeks Baseline	5th Week	10th Week	14th Week
Sugar Snack Test (SST)	5	5	4	3
Saliva Secretion Rate (SSR)	3	1	1	1
Plaque Score	5	2	3	1
mutans Streptococcus (SM)	5	5	3	1
Buffering Capacity (BC)	4	4	4	3
Lactobacilli (Lb)	5	5	5	5
Diet	5	5	5	5
Decayed Teeth (DT)	0	0	0	0
Decayed, Missing, Filled Surfaces (DMFS)	53	53	53	53
* shading & enlarged number font represent a change in the test result from the previous test	Treatments Between Tests	OHI	OHI 1% NaF	OHI 0.2% NaF 0.2% CHX

Table 4: Summary of case report test results.

Below is a simplified school/group version of the SST called the ToothSaver Team.

It is four-sided and printed on heavy paper and folded into pages 1-4. Pages 1 and 4 are the front and back and pages 2 & 3 are the instructions and SST.



SIMPLE RULES FOR SAVING TEETH

THE TABLE IS WHERE YOU SHOULD EAT   If you are hungry then prepare some good food and eat it at the kitchen or dining table. Eat enough to last until the next meal.

FIVE MEALS — NO SNACKS   Every time you eat or drink (except water) your bacteria produce acid. Saliva cannot protect your teeth if you eat more than five times a day. Bacteria like snacks and hate meals. Instead of a snack have a small meal.... at the table.... without TV.

EAT WHEN HUNGRY — STOP WHEN FULL
SNACKS DON'T LAST — GOOD MEALS DO

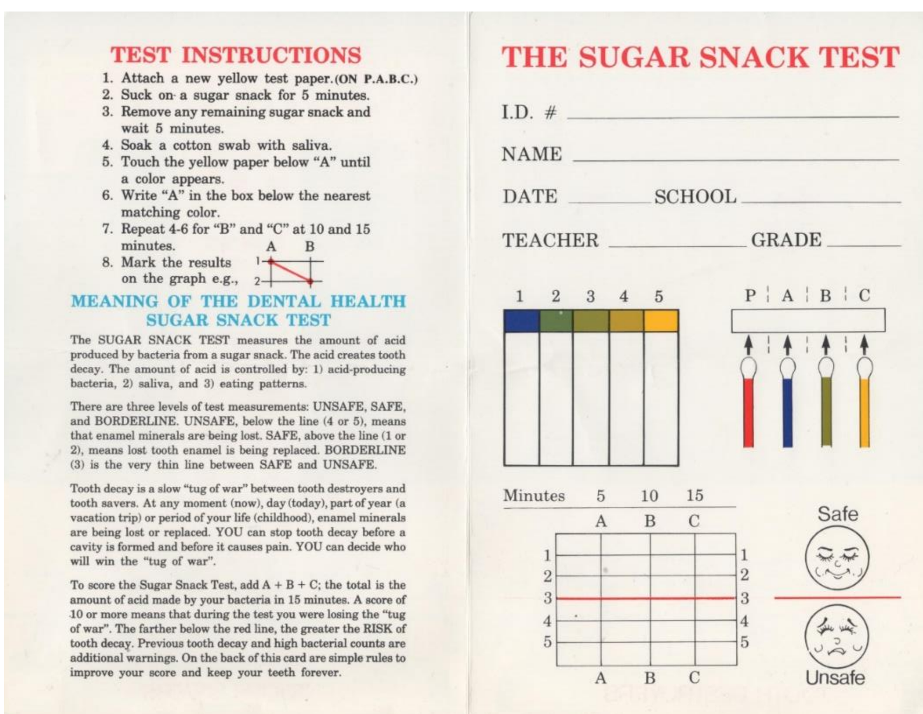
THREE HOURS BETWEEN MEALS   It takes three hours for saliva to remove the acid made by the bacteria and to replace the lost tooth enamel. If you eat too soon then some of the lost enamel will not be replaced.

TELEVISION AND EATING DO NOT MIX   When you eat while watching TV the bacteria have a long time to make acid and dissolve your teeth.

FLOSS WITH FLUORIDE EVERY DAY   Battle the bad bacteria by flossing fluoride toothpaste between the back teeth. Fluoride reduces acid and strengthens enamel.

TEETH ARE FOREVER   Your first set of teeth are meant to stay until they are replaced naturally by the second set which should last the rest of your life IF you follow these simple rules for saving teeth!

TOOTH SAVER TEAM



TEST INSTRUCTIONS

1. Attach a new yellow test paper.(ON P.A.B.C.)
2. Suck on a sugar snack for 5 minutes.
3. Remove any remaining sugar snack and wait 5 minutes.
4. Soak a cotton swab with saliva.
5. Touch the yellow paper below "A" until a color appears.
6. Write "A" in the box below the nearest matching color.
7. Repeat 4-6 for "B" and "C" at 10 and 15 minutes.
8. Mark the results on the graph e.g.,

MEANING OF THE DENTAL HEALTH SUGAR SNACK TEST

The SUGAR SNACK TEST measures the amount of acid produced by bacteria from a sugar snack. The acid creates tooth decay. The amount of acid is controlled by: 1) acid-producing bacteria, 2) saliva, and 3) eating patterns.

There are three levels of test measurements: UNSAFE, SAFE, and BORDERLINE. UNSAFE, below the line (4 or 5), means that enamel minerals are being lost. SAFE, above the line (1 or 2), means lost tooth enamel is being replaced. BORDERLINE (3) is the very thin line between SAFE and UNSAFE.

Tooth decay is a slow "tug of war" between tooth destroyers and tooth savers. At any moment (now), day (today), part of year (a vacation trip) or period of your life (childhood), enamel minerals are being lost or replaced. YOU can stop tooth decay before a cavity is formed and before it causes pain. YOU can decide who will win the "tug of war".

To score the Sugar Snack Test, add A + B + C; the total is the amount of acid made by your bacteria in 15 minutes. A score of 10 or more means that during the test you were losing the "tug of war". The farther below the red line, the greater the RISK of tooth decay. Previous tooth decay and high bacterial counts are additional warnings. On the back of this card are simple rules to improve your score and keep your teeth forever.

THE SUGAR SNACK TEST

I.D. # ______

NAME ______

DATE ______ SCHOOL ______

TEACHER ______ GRADE ______

Materials & Equipment List for Caries Risk Assessment

ITEM	DESCRIPTION	COMMENT
SUGAR SNACK TEST FORM	PROVIDED	Copyright 1987, Martin MacIntyre
HOLDER FOR MATERIALS	SMALL SNACK PLASTIC BAG	sealable
ORAL pH PAPER	SALIVA ACIDITY TEST PAPER Color scale for pH 5.0 | 5.5 | 6.0 | 6.5 | 7.0 Equiv. SST scale 5 | 4 | 3 | 2 | 1	pHydrion ® 4.5 - 7.5
TRANSPARENT TAPE		Attached the pH paper. Tape back of the form underneath the pH paper to stop leaking Tape over pH paper at end of test.
MINUTE TIMER	TIMER	Preferably with alarm
PEN	WIDE FELT TIP, WATER SOLUBLE	red, green or blue
COTTON SWABS	ONE END OF A COTTON SWAB	Q-tip can be cut in half for 2 uses.
FACIAL TISSUE	ONE SMALL TISSUE	For wiping the mouth
SUGAR CHEWING GUM	SUCROSE, NO FRUIT FLAVORING	any
SUGAR MINT	SUCROSE MINT FLAVORED HARD	non-fruit
SUGARLESS GUM	SWEET AND FLAVORED (no fruit)	a variety for patient choice

Sugar Snack Saliva Test Summary

- Place a new oral pH paper on the Test form and attach each end with adhesive tape.
- Place the Test form on the table.
- Place the storage bag with the required supplies above the test form.
- When the patient is seated explain the purpose of the test and how it will be conducted.
- To obtain saliva samples, have the patient put the end of a cotton swab into their mouth and swish saliva around until the end of the swab is soaked.
- Take the swab and demonstrate how to touch the end of the soaked swab on the pH paper just above the arrow.
- Wait ten seconds and coach the patient in comparing the color on the paper with the Saliva Test Acidity Color Scale.
- Help the patient locate the point on the graph that corresponds with the color (1-5).
- Have the patient mark the first point on the graph with a felt-tip pen.
- Continue to collect saliva samples with the cotton swab at the indicated intervals
- After each marking, have the patient connect the dots and then explain the purpose of this segment of the test, the anticipated result and the possible explanation of the actual result. Encourage questions.
- At the completion of the test, place transparent tape over the pH paper (infection control). There should be tape on the reverse side of the paper before starting the test.
- Score the test and circle all tests that were completed and the treatment that is planned.
- Copy the form, give a copy to the patient and place the original in the patient's record.

Appendix A

Saliva secretion rate tests procedure and explanation

If the size of the marks on the oral acidity test paper made by a soaked cotton swab is smaller than the end of the swab and doesn't respond normally to stimuli, then more specific tests are required. These should be completed at a separate appointment and at a specific time that can be repeated to confirm the results. Ideally this should be between meals. The saliva secretion rate tests described here are designed to distinguish between the different stimuli in order to determine the reason for the lack of saliva or in some cases excess saliva. The cause of both extremes can usually be determined by thorough questioning of the patient concerning, symptoms, medications, medical conditions and habits. The tests are used to try to confirm the initial diagnosis and to rule out other possibilities.

Resting (unstimulated) secretion rate:

This is collected by allowing saliva to collect in the front of the mouth for 5 minutes following the 'C' reading. This represents the saliva available to neutralize acid following a feeding. ≤ 0.2 ml./min. is high risk. This test is used when the clinician thinks there might be a low secretion rate. It indicates the amount of saliva available to clear the mouth of food and to neutralize the acid when there is no physical stimulation (taste, smell, feel, sight). This could be low and still have a normal stimulated secretion rate. It is significant because it represents the majority of the patient's time over a 24- hour period. It is between meals, when the bacteria face the least amount of resistance, that the caries process takes place. Holding the saliva in the mouth without swallowing the saliva for five minutes before expectorating produces the most consistent results. Any secretion rate less than 0.1 ml/min warrants retesting on another day unless there is a low caries risk, or an obvious explanation for the low rate. The test is performed at the end of the sugar snack test (15 minutes after sugar is removed from the mouth) to ensure a standard experience preceding it and a minimum effect from psychological factors, such as patient apprehension, that might exist at the beginning of the test.

Chewing-stimulated secretion rate:

Saliva is the major natural resistance against caries. It helps clear harmful foods, coats the teeth, fights harmful bacteria and provides the Ca and P needed for remineralization. When the SSR is very low, the risk of caries is extremely high. Chewing-Stimulated Secretion Rate is the volume of saliva produced per minute chewing paraffin. The normal rate is 1.0 ml/min or more, and less than 0.4 ml/min is a risk factor. When this is part of the Sugar Snack Test it is not necessary to measure the amount of saliva. Instead note the circumference of the wet mark. If it is less than the circumference of the swab, then the following tests are needed.

Sugar & chewing secretion rate:

This is collected after the resting secretion rate by chewing sugarless sweet gum for 3 minutes. This represents the saliva produced from maximum stimulation -- ≤ 0.6 is high risk. This procedure has diagnostic and patient management purposes. With respect to patient management, if the secretion rate is normal, but the final reading ("C") is acidic, this procedure brings the patient above the line in the safe area and shows that it is possible to be safe and it is not complicated or difficult or unpleasant to reach this condition. This procedure combines two stimulants and should elicit the patient's maximum salivary response. A non-acid fruit flavored, sweet be used, but sugarless chewing gum is the ideal stimulus. It usually reduces the acidity to a level that is less than 3 and is usually 1. This is to be expected in almost everyone, since the normal stimulated level is 1 and it is the saliva that is being tested. If this is successful and the use of gum is part of the treatment regimen, this procedure will enhance the patient's acceptance of the treatment plan.

If the secretion rate is still a low, then one or more of the following explanations must be determined:

1) There is a lack of saliva-secreting cells;

2) There is a blockage in the ducts (it is unlikely that they are all blocked);

3) These stimuli are not being read or accepted or communicated to the glands.

The normal rate is 1.0 cc/min or more. Smaller individuals have a lower volume, and, on the average, women have lower volumes than men, perhaps for reason of size. Children are highly unpredictable as is the case with many other bodily function tests. If the initial level is less than 1.0 cc/min. then you should consider the following explanations before assuming that the saliva production is pathologically or inherently low:

1. Has the patient swallowed saliva during the test?

2. Is the patient nervous?

3. Is the patient dehydrated from simply not drinking water during hot weather, during recent heavy exercise, or for religious reasons?, e.g. no daytime fluid intake for other reasons, e.g. during Ramadan.

4. Are there other unintended stimuli that might cause the saliva to flow or not flow?, e.g. taste, smell, or sight of food.

Beyond the normal stimuli of sweet, chewing, acid and bitter, the stimuli that cause saliva to secrete can be very specific and individualized. In fact, a stimulus for one person can literally "turn off" the saliva secretion for another person. This even includes chewing and sweet stimuli. A sweet, flavored chewing gum will usually produce a maximum reaction and help to reduce false positives. Questioning and observing the patient can provide clues to a dry mouth syndrome. Are the lips dry? Do the lips smack or foam when talking? Are there signs of salivary duct inflammation? Does the patient admit to having a dry mouth? Medication is the most likely source of low saliva output, followed by insufficient fluid intake. Medications such as antihistamines, beta blockers, diuretics, mood altering drugs and many others can reduce salivary flow. Reduced saliva flow is a prime factor in dental caries along with diet. Saliva helps to clear harmful food from the mouth; it coats the teeth and protects them, it contains many enzymes and anti-enzymes that work against cariogenic bacteria (lysozymes, lactoferrins, lactoperoxidase, sialin) and it also contains salivary buffers and immunoglobulins and dilution. When the saliva output is low the risk of caries activity is extremely high.

“I am pleased to say that Dr. Graham Craig has allowed us to re-publish material from his remarkable Handbook on atraumatic dental techniques as a separate chapter in this textbook. I encourage the reader to watch his interviews as well.” – Dr. Steven Duffin

- http://mmclibrary.com/Dr_10.html

Dr. Graham Craig’s wonderful full text is available at: www.dentaloutlook.com.au

References

Anders Thylstrup, & Ole Fejerskov. (1986). Textbook of cariology (pp. 249–250). Copenhagen: Munksgaard, Cop.

Bibby, B. G., Mundorff, S. A., Zero, D. T., & Almekinder, K. J. (1986). Oral food clearance and the pH of plaque and saliva. The Journal of the American Dental Association, 112(3), 333–337. https://doi.org/10.1016/s0002-8177(86)23012-3

Bohannan, Disney et. al. (n.d.). Robert Wood Johnson Study Report.

Bowen, W. H. (1991). Dental caries: Is it an extinct disease? The Journal of the American Dental Association, 122(9), 49–52. https://doi.org/10.14219/jada.archive.1991.0268

Carlos, J. P. (1978). In Proceedings Methods of Caries Prediction. Ebs. Bibby and Shern. Sp., Supp. Microbiology Abstracts, IRL, 1-2.

Carounanidy, U., & Sathyanarayanan, R. (2009). Dental caries: A complete changeover (Part II)-Changeover in the diagnosis and prognosis. Journal of Conservative Dentistry, 12(3), 87. https://doi.org/10.4103/0972-0707.57631

Edgar, W. M. (1976). The Role of Saliva in the Control of pH Changes in Human Dental Plaque. Caries Research, 10(4), 241–254. https://doi.org/10.1159/000260206

Edgar, W. M., Bibby, B. G., Mundorff, S., & Rowley, J. (1975). Acid production in plaques after eating snacks: modifying factors in foods. The Journal of the American Dental Association, 90(2), 418–425. https://doi.org/10.14219/jada.archive.1975.0099

Ellen, R. P. (1976). Microbiological assays for dental caries and periodontal disease susceptibility. Oral Sciences Reviews, 8, 3–23.

Ericsson, Y. (1949). Investigations into the calcium phosphate equilibrium between enamel and saliva and its relations to dental caries. Acta. Odont. Scand., 8, supl. 3.

Firestone, A. R., & Muhlemann, H. R. (1985). In Vivo ph of plaque-covered and plaque-free interdental surfaces in humans following a sucrose rinse. Clinical Preventive Dentistry, 7(4), 24–26.

Greene (1998). Personal Communication.

Hardwick, J. L. (1960). A Clinical Assessment of the Accuracy of the Methyl Red Test in Forecasting Caries. British Journal of Dentistry, 108, 255-259.

Hardwick, J. L., Manley, E. B. (1952). Caries of the enamel and acidogenic caries. British Dental Journal, 92, 225-236

Imfeld, T. N. (1983). Identification of low caries rick dietary components. Monographs of Oral Science, 11, 1–198.

Imfeld, T., Hirsch, R. S., & Muhlemann, H. R. (1978). Telemetric recordings of interdental plaque pH during different meal patterns. British Dental Journal, 144(2), 40–45. https://doi.org/10.1038/sj.bdj.4804020

Kleinberg, I., & Jenkins, G. N. (1964). The pH of dental plaques in the different areas of the mouth before and after meals and their relationship to the pH and rate of flow of resting saliva. Archives of Oral Biology, 9(5), 493–516. https://doi.org/10.1016/0003-9969(64)90015-9

Krasse, B. (1985). Caries risk : a practical guide for assessment and control. Chicago: Quintessence Pub. Co.

Larsen, M. J. (1973). Dissolution of enamel. European Journal of Oral Sciences, 81(7), 518–522. https://doi.org/10.1111/j.1600-0722.1973.tb00358.x

Loesche, W. J. (1984). Dental Caries: a Treatable Infection. Thomas.

Minah, G. E., & Loesche, W. J. (1977). Sucrose metabolism by prominent members of the flora isolated from cariogenic and non-cariogenic dental plaques. Infection and immunity, 17(1), 55–61.

Newbrun, E. (1983). Cariology. Baltimore: Williams & Wilkins. 256-257.

Nikiforuk, G. (1985a). Understanding dental caries / Vol.1 Etiology and mechanisms, basic and clinical aspects. (pp. 225–226). Basel ; New York: Karger.

Parkins, F. M. (1978). In Proceedings Methods of Caries Prediction. Eds. Bibby and Shern Sp., Supp., Microbiology Abstracts, IRL, 5-6.

Rapp, R. P. (1963). Fifteen-minute caries test. Ill. Dent. J., 31, 290.

Snyder, M. L. (1951). Laboratory Methods in the Clinical Evaluation of Caries Activity. The Journal of the American Dental Association, 42(4), 400–413. https://doi.org/10.14219/jada.archive.1951.0065

Socransky, S. S. (1968). Caries-Susceptibility Tests. Annals of the New York Academy of Sciences, 153(1 Evaluation of), 137–146. https://doi.org/10.1111/j.1749-6632.1968.tb11732.x

Stephan, R. M. (1940). Changes in Hydrogen-Ion Concentration on Tooth Surfaces and in Carious Lesions. The Journal of the American Dental Association, 27(5), 718–723. https://doi.org/10.14219/jada.archive.1940.0178

Stephan, R. M. (1944). Intra-Oral Hydrogen-Ion Concentrations Associated With Dental Caries Activity. Journal of Dental Research, 23(4), 257–266. https://doi.org/10.1177/00220345440230040401

van Houte, J., Winkler, K. C., & Jansen, H. M. (1969). Iodophilic polysaccharide synthesis, acid production and growth in oral streptococci. Archives of Oral Biology, 14(1), 45–61. https://doi.org/10.1016/0003-9969(69)90020-x

Technique Notes for Atraumatic Procedures for Child Patients in Outreach Dental Programmes

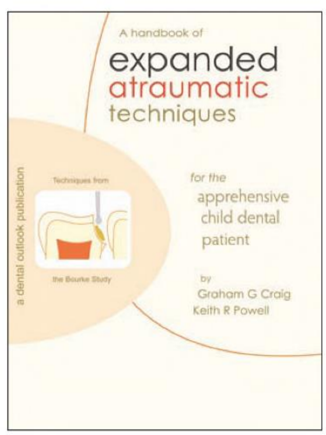
(Dr. Graham Craig, AM, MDS, PhD)

TECHNIQUE NOTES

for

Atraumatic procedures for child patients in outreach dental programmes.

by Graham G Craig and
Keith R Powell



Based on 'A Handbook of Expanded Atraumatic Techniques for the Apprehensive Child Dental Patient' by GG Craig and KR Powell. Dental Outlook Publications, 2013.

Foreword:

hese notes are divided into 3 sections to correspond to the various situations encountered, including patient co-operation, and the dental equipment available for the treatment of open carious lesions in primary molar teeth:

1. Chemical treatments.
2. Interim restorative treatments.
3. Restorative treatments requiring rotary instruments.

All relevant references and photographs of cases followed for up to 4 years can be found in 'A Handbook of Expanded Atraumatic Techniques for the Apprehensive Child Dental Patient' by GG Craig and KR Powell. Dental Outlook 2013.

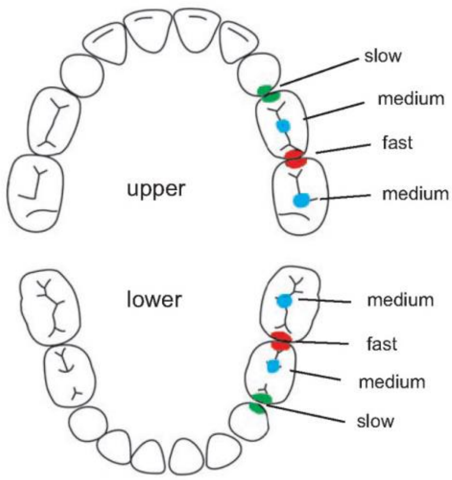
Available from Dental Outlook Publications
www.dentaloutlook.com.au

Email for GG Craig - dentaloutlook@bigpond.com

Begin by looking at the existing lesions

- ## Where are they located?

Although it may vary from one population group to another, there are some general guidelines as to which lesions in primary molars that tend to progress rapidly and those that do not. This is illustrated below:



Summary

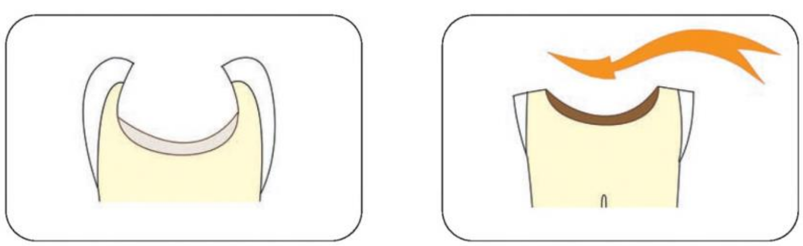
Fast progression
- Distal of first primary molars.
- Mesial of second primary molars.
- Distal of second primary molars (when first permanent molars have erupted).

Medium progression
- Occlusal of first and second primary molars.

Slow progression
- Distal of canines.
- Mesial of first primary molars.
- Smooth facial surfaces of primary molars.

- ## How open are the lesions?

As a general observation the more open a lesion is to saliva, the slower its progression.



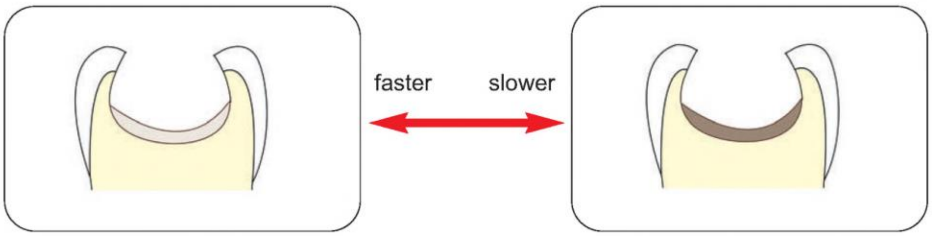
Above: The simple act of opening up a carious lesion (left) to the action of saliva can result in the arrestment or slowing down of the lesion (right).

Saliva has a good buffering and remineralising capacity and its effect can be utilised in the treatment of open carious lesions in primary molars.

Looking at the existing lesions (cont)

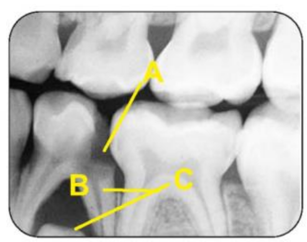
- What colour are the lesions?

Invariably darker lesions are progressing more slowly than lighter-coloured ones and, whilst probing of a lesion is best avoided, the darker-coloured ones are usually firmer.



- If bite-wing radiographs can be taken....

A considerable amount of very useful information can be obtained from bite-wing radiographs of primary molar teeth particularly regarding lesion depth of approximal surface and occlusal lesions. Unlike the situation with permanent teeth, in primary molar teeth the radiographic depth of a lesion usually corresponds very closely with the clinical depth.



Information that can be obtained from bitewing radiographs includes:
A. Depth of approximal surface and occlusal lesions.
B. Presence of furcation pathology.
C. Degree of root resorption and position of permanent successor.

Summary:

The fact that a lesion may look large does not necessarily mean that it is progressing rapidly. The above information can help differentiate the lesions that are likely to progress quickly as against those with a lower priority.

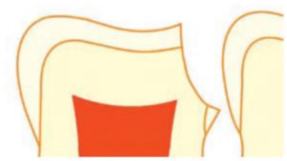
Chemical treatments

- Technique

A simple atraumatic start, especially for apprehensive child patients , is the use of 40% silver fluoride on open carious lesions in vital, asymptomatic primary molars. A number of clinical studies have shown the usefulness of silver fluoride preparations in the treatment of open carious lesions in primary teeth.

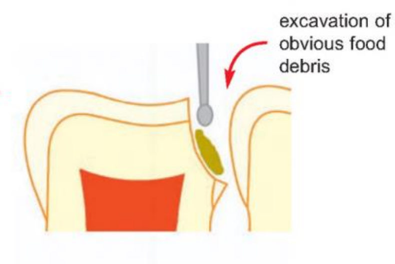
If bite-wing radiographs are available there should be approximately 0.5 mm or more of radiographically sound dentine from the base of the lesion to the pulp for open occlusal or approximal surface lesions.

a.



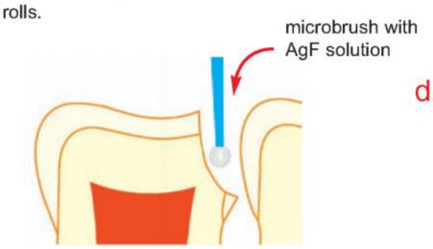
If the tooth is vital and there has been no history of pain the tooth to be treated is isolated with cotton rolls.

b.



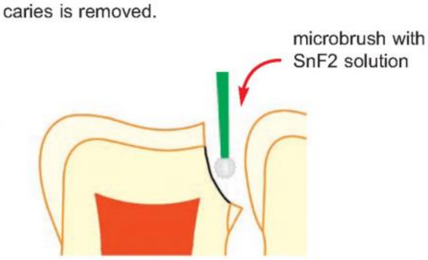
Any obvious food debris is removed with an excavator. No caries is removed.

c.



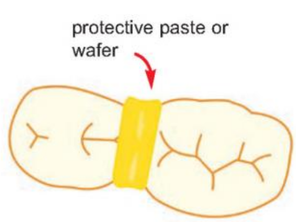
The silver fluoride AgF preparation is applied on a microbrush and the site is kept wet with the solution for at least one minute.

d.



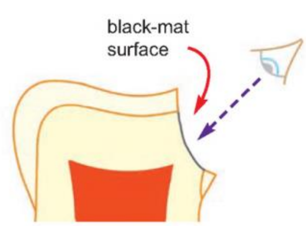
After the silver fluoride application period 10% stannous fluoride (SnF_2) is applied as a reducing agent to turn the surface of the lesion black.

e.



The treated site is temporarily covered with **Orabase Protective Paste** (Convatec). Experienced operators may prefer to use a piece of **Stomahesive Wafer** (Convatec).

f.



A few days later the surface of the lesion is examined to see if the entire surface has a black mat appearance. If it does not, the non-pigmented area is inspected to ensure it is not a pulp exposure. If this is not the case, repeat the above steps.

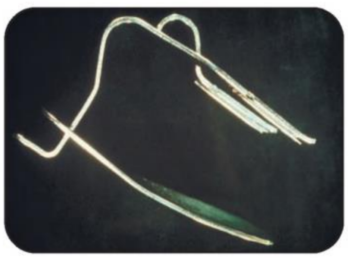
Chemical treatments (cont)

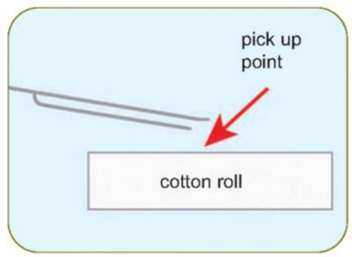
- Useful items

Silver fluoride and stannous fluoride

Open lesions are treated with 40% silver fluoride (left) for at least one minute followed by the use of 10% stannous fluoride paste (right) as a reducing agent. Both products were produced by Creighton Dental, Sydney.

Garmers cotton roll holders

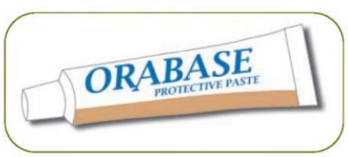




Junior **Garmers Cotton Roll Holders** (Garmers) are ideal for lower arch isolation. They have the additional advantage of removing the need for high volume aspiration and the accompanying noise that may have upset some apprehensive young patients.

Tip: When using **Garmers Cotton Roll Holders** the cotton roll is picked up with the prong *half-way* along the roll, not at the end. This makes seating far easier.

Temporary covering

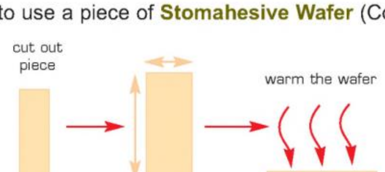


Left: Even though it does not stay as long as the wafer (below), **Orabase Protective Paste (Convatec)** is easy to apply with the gloved finger.

Below: Experienced operators may prefer to use a piece of **Stomahesive Wafer** (Convatec):

Piece of **Stomahesive Wafer** with backing removed.

Treated site covered by a piece of **Stomahesive Wafer**.



Technique: For a small piece of **Stomahesive Wafer** to adhere properly to tooth structure, it has first to be thinned and then warmed. Thinning can be achieved by pressing it between two glass slabs and it can be warmed by the patient holding the piece in his or her hand. It is adapted with firm pressure on sound tooth structure making sure the edges are completely sealed. After adaptation the wafer is left to dissolve in the oral fluids.

Chemical treatments (cont)

- How do you know it has worked?

One of the advantages of using stannous fluoride one minute or more after the application of 40% silver fluoride is that it turns the surface of the carious lesion black. This is a valuable indicator because if the surface becomes lighter it is an indication that the lesion may be progressing and needs closer inspection.

In addition the distinctive black colour provides an indicator to other operators not to intervene. Some procedures, such as with nano-silver, do not stain the surface of a lesion. In these circumstances it can be very difficult for an operator to determine whether a lesion is stationary or progressing. Probing a surface, especially when the lesion is deep, can produce iatrogenic damage.

Above: After the silver fluoride/stannous fluoride treatment, the continuing presence of a black mat on the surface of the lesion is a strong indicator that the lesion is static.

Above: Loss of the black matt surface at some stage after the silver fluoride/stannous fluoride treatment as shown is indicative of lesion progression.

Treatments can be repeated if lesion lightening does occur.

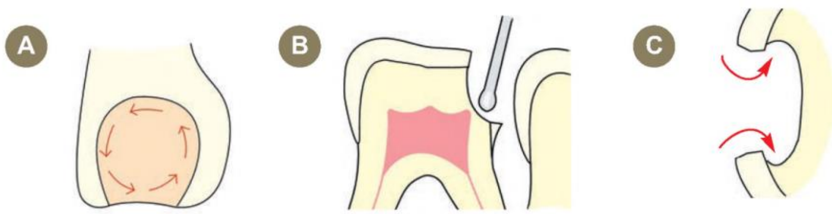
Interim restorative treatments

• Background

A standard part of the Atraumatic Restorative Technique (ART) is the use of hand instruments to remove caries and prepare a cavity. However, there are a number of subtle points that have to be kept in mind when using the ART technique on open lesions in primary molars.

• Excavating caries

The excavation technique shown below involves starting at the periphery of the lesion and working inwards. The natural undercuts produced by the lateral spread of caries just inside the dentino-enamel junction are used to assist in retention of the restoration.



Caries is gently excavated starting at the periphery of the lesion.

The outer areas are freed of decay before working inwards.

To assist retention of the restoration, utilisation is made of the natural undercuts just inside the dentino-enamel junction produced by the slight lateral spread of the lesion.

• Grades of difficulty

The length of service of an interim restoration, where cavity preparation is carried out with an excavator alone, can vary with the site of the lesion. It is usually easy to obtain reasonable longevity for occlusal lesions and hardest for lesions on the distal surface of first primary molars.

easiest ⟶ hardest

Occlusal lesions.

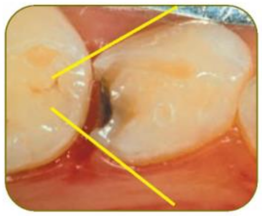
'Box-type' approximal surface lesions in second primary molars.

'Box-type distal surface lesions in first primary molars.

Wide, but shallow, distal surface lesions in first primary molars.

Interim restorative treatments (cont)

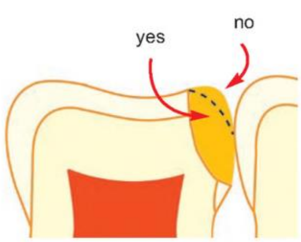
It can be extremely difficult to retain an interim restoration in the distal section of a lower first primary molar. The taper of the facial and lingual surfaces towards the distal plus the relatively thin enamel makes retention a problem with 'box only' preparations.



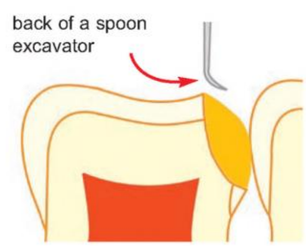
The taper of the facial and lingual surfaces towards the distal plus the thin enamel in first primary molars can make the retention of 'box only' restorations a problem in this area.

As a first step, a 'box only' preparation may have to be used. The life-span of this type of restoration is likely to be limited and, as a longer-term solution, it may be necessary to place a restoration with an occlusal lock.

- Contour of an approximo-occlusal interim restoration



To increase the longevity of interim approximo-occlusal restorations the marginal ridge height is lowered as shown.



After placement of the glass-ionomer cement, the back of a spoon excavator is used to achieve the appropriate contour.

<u>Note</u>: Unlike the situation with permanent teeth, the contact area with approximo-occlusal restorations in primary molars only needs to be at some point above the gingival margin to prevent food impaction.

- Materials

As in ART, high-viscosity, glass-ionomer cement is the preferred restorative materials for interim restorations. However, some operators have had good results with *<u>very</u>* *<u>thickly</u>* mixed **IRM** (Dentsply).

Use of rotary instruments

- Increasing salivary access to a lesion

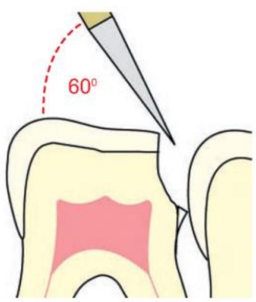
Rotary instruments can be useful in increasing salivary access to a lesion. Two methods are shown below:

<u>Ingers' Technique</u>:

With a co-operative patient, the Ingers' Technique is extremely useful for handling the problem of disto-occlusal cavities in first primary molars.

It can be used when there is no gap between the first and second primary molars at the level of the gingival margin.

For the Ingers' Technique to be used there must be no gap at the gingival margin between the first and second primary molars.

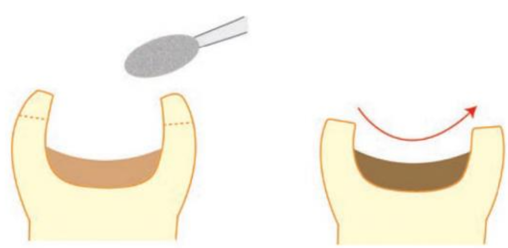


With the Ingers' Technique a slice is made with a tapering diamond bur at an angle of approximately 60 degrees or less.

The remaining caries is removed and a simple 'box-type' restoration placed.

<u>Cusp reduction</u>:

Cusp reduction can be used to open up a carious lesion to the action of saliva.

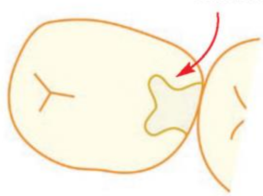


An oval-sped diamond bur can be used for cusp reduction and so open up a lesion to the action of saliva.

Use of rotary instruments (cont)

• Preparation of an occlusal lock

To increase the longevity of disto-occlusal restorations in first primary molars it may be necessary to place and occlusal lock.

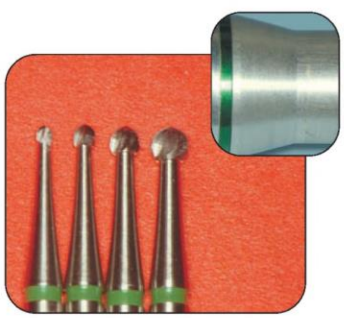


The preparation of an occlusal lock follows the shape shown and is carried out with round burs rotating slowly in an ultra-low speed hand-piece. Care should be taken to ensure that there is at least a small periphery of sound dentine, just inside the dentino-enamel junction, on the gingival floor and the buccal and lingual walls.

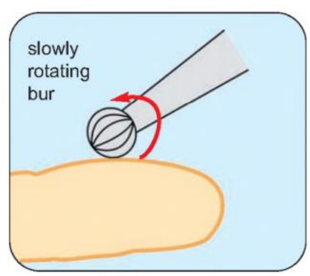
• Use of ultra-low speed cutting

Ultra-low speed cutting can be very useful for cavity preparation in primary teeth. It has been found that *pressure* from a slow moving round bur tends to cause little or no discomfort whereas *vibration* does.

Tooth structure of primary teeth can be removed cleanly and efficiently by using sharp round tungsten carbide burs in a handpiece rotating at around 100 to 200 rpm.



Example of sharp round tungsten carbide burs that can be used to prepare retentive features for restorations in primary molar teeth. They are used at 100-200 rpm in a reduction handpiece (inset). These handpieces are commonly identi-fied by a green band on the shank.



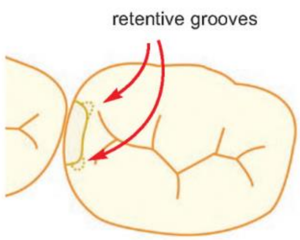
To reduce apprehension when working without local anaesthesia it is a good idea to first run the round bur on the child's finger at a slow speed.

Use of rotary instruments (cont)

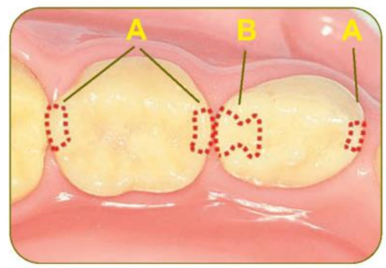
- Cavity preparation for second primary molars

As with disto-occlusal cavities in first primary molars, all the cavity preparation is carried out with round burs. However, because of the greater thickness of enamel it is invariably not necessary to prepare an occlusal lock.

There is usually sufficient room to prepare adequate retentive grooves in the buccal and lingual walls of the approximal box. A periphery of sound dentine, is prepared just inside the dentino-enamel junction, on the gingival floor and the buccal and lingual walls.



Placing retentive grooves just inside the dentino-enamel junction in an approximal box as illustrated can be used to increase the longevity of mesio-occlusal and disto-occlusal restorations in second primary molars.



Outline of cavity preparations used on approximal surfaces of first and second primary molars.

A = 'box' type. B = with occlusal lock.

Relief of pain

• Main causes of pain in primary molars

Food impaction

Food impaction as shown is a common cause of pain in the primary dentition. It can be misinterpreted as a sign of an abscess.

The main causes of pain in the primary dentition appear to be:

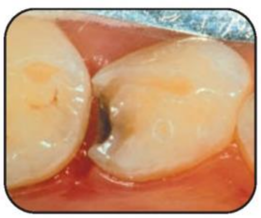
• Pain from food impaction.

• Pain from tooth mobility caused either by imminent exfoliation or a chronic alveolar abscess.

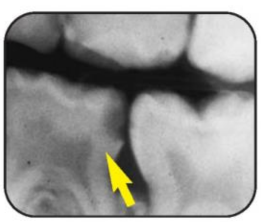
• Possibly pulpitis.

• Very early stages of a chronic alveolar abscess before the abscess has pointed.

• Acute alveolar abscess (fortunately fairly rare in the primary dentition).



Photograph showing impacted food removed. Note how the impaction produced a distinct crater in the gingival tissue.



A the bite-wing radiograph showed the presence of a distinct layer of sound dentine between the base of the lesion and the pulp. This is a useful indicator that the cause is not of pulpal origin.

Treatments:

Pain from food impaction:

Recognition:

• Patient complains of pain when chewing fibrous foods such as meat or chicken.

• There is an approximal surface lesion with the overlying marginal ridge broken away.

• Close inspection shows fibrous food remnants jammed between the teeth.

• Examination of the bite-wing radiograph shows *a definite layer of sound dentine* between the base of the lesion and the pulp.

Be aware of a common mistake:

A common mistake is interpreting 'pain on chewing' as a sign of an abscess. All indicators should be taken into account before a final diagnosis is made.

Treatment:

• The jammed food remnants are teased out carefully in an *occlusal* direction with the end of an explorer. Care should be taken not to push impacted items towards the gingival margin as this could invoke a pain response.

• Place a temporary restoration.

• Recall the patient the next day to ensure that the symptoms have subsided.

• Restore the tooth.

Relief of pain (cont)

Treatments (cont)

Food impaction (cont)

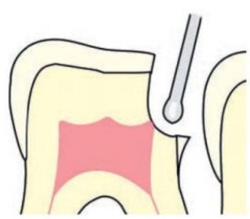
Once impacted food is removed a temporary restoration is placed. The patient is recalled the next day to ensure that the symptoms have subsided. The tooth is subsequently restored.

Other pulp treatments

The other pulpal problems encountered with carious primary molars are a chronic alveolar abscess and an acute alveolar abscess .Traditional treatment carried out by the authors used **Kri 1 Paste** (Pharmachemie) and **Ledermix Paste** (Lederle). However, **Kri 1 Paste** is no longer marketed and so an alternative is required (see box next page).

Chronic/acute abscess

Bite-wing radiograph shows caries has reached, or is extremely close to, the pulp.



It was important to excavate right up to the point where vital tissue is encountered.

Treatment:

Pain from pulpal involvement:

Recognition:

• Indications from patient history.

• The possible presence of swelling etc.

• Evidence from a bite-wing radiograph that caries had reached the pulp.

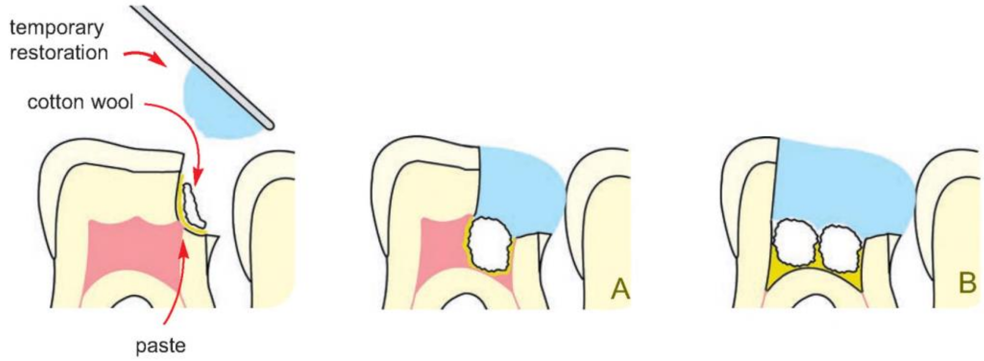
Technique:

(The process can be carried out *without* anaesthesia but requires proceeding with caution).

• Caries is excavated *right up to* the point where vital tissue is encountered. (Quite frequently primary molar teeth exhibiting signs of a chronic alveolar abscess can have pulps which, clinically at least, are completely vital).

• If the pulp chamber is reached without encountering any vital tissue, the pulp chamber is entered and progress stopped when any vital tissue was reached. (If the pulp chamber is free of vital tissue, and the patient is co-operative, the roof is removed with a tapering bur in a high speed handpiece to gain better access).

Relief of pain (cont)



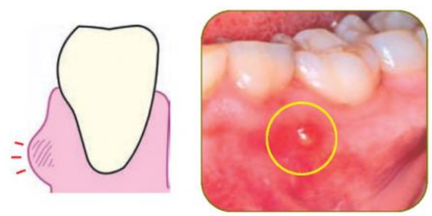
The exposure site is covered with the iodoform/*Ledermix* mixture. A piece of flattened cotton wool is placed on top and tamped into position. Finally the temporary restoration is inserted.

Depending on the presence or absence of vital tissue the final dressing can be either like (a) or (b) above. Interestingly, the iodoform/*Ledermix* combination tends to have a devitalising effect on remaining pulp tissue which makes the subsequent root filling a lot easier.

<ins>Two types of chronic alveolar abscess</ins>:

One type of chronic alveolar abscess points at or near the gingival margin, often occurs just before a badly broken down tooth exfoliates.

Tooth mobility is often the main cause of the discomfort in these cases.



Another type of chronic alveolar abscess points in a region adjacent to a root apex (shown above) tends to be associated with a more long-standing pulpal involvement.

Quite often the patient is unaware that the abscess is present.

<ins>Chronic alveolar abscess:</ins>

<ins>Treatment</ins>:

The treatment with iodoform/*Ledermix* paste as outlined above is followed. With chronic alveolar abscesses experience has shown that vital tissue may still be present (often in the pulp chamber or root canal furthest away from the pulp exposure site). Furthermore, in some primary molar teeth >

Alternative to Kri 1 Paste

80.0% iodoform
20.0% silicone oil
(mix and homogenise)

Relief of pain (cont)

Treatments (cont)

Chronic alveolar abscess:

Treatment: (cont)

showing signs of a chronic alveolar abscess, the pulp clinically appears to be vital. In such cases it is possible that the abscess represents an escape of inflammatory exudate from the pulp rather than pus.

When treating teeth with a chronic alveolar abscess no attempt is made to ream and file the root canals, instead try and introduce > some iodoform/ *Ledermix* paste into a root canal with the point of a probe.

Acute alveolar abscess:

Treatment:

Conservative treatment may be difficult, however, the course of treatment outlined for a chronic alveolar abscess in combination with antibiotic treatment has been found to be successful.

Other conditions

Chronic hyperplastic pulpitis:

A condition that can be associated with grossly carious primary teeth is chronic hyperplastic pulpitis. In this situation tissue grows out from the exposure site into the cavity. When it occurs it appears to cause little or no discomfort to the patient.

Root stumps:

A root stump may be able to be retained and act as a space maintainer. However, even if not causing pain, a root stump should be removed if it is causing deflection of the permanent successor.

Section Four: Social Determinants of Disease, Economics, and Policy

Social Determinants of Disease

(Dr. Steve Duffin, DDS and Jacqueline Juhl, RDH, BS, MS)

Caries is an opportunistic disease; it preys on the poor, the infirm and the disadvantaged segments of society. Unlike the bubonic plague long ago that claimed rich and poor alike, caries seems to have clustered in certain population groups over time. The examination of ancient skulls demonstrates that caries was present in early man, although rarely a significant problem. This situation changed with the introduction of carbohydrate rich agricultural products. Caries rates started to increase in prevalence among segments of the population with access to cultivated grain-based foods. There is no evidence that caries rates in early man was related to social status. With the proliferation of cane and beet sugar and the ability of wealthy people to purchase this scarce and rare commodity, caries began to be a significant problem for the affluent. The very beginnings of the dental profession in the mid 1700's can be directly linked to the development of sugar plantations around the world. Pierre Fauchard was the first person to write a complete text on the care of teeth and repair of the effects of caries, "The Surgeon Dentist" in 1728.

From 1500 until approximately 1900, caries remained a disease of the affluent. Weston Price described in his text "Nutrition and Physical Degeneration" how individuals throughout the world had few cavities if they did not consume processed foods. When modern sugar enhanced foods were introduced, the decay rates rapidly increased.

Following the discoveries of W. D. Miller. G. V. Black and Weston Price between 1880 and 1950, the understanding of the role of sugar in the cause of caries became well known. High caries rates in populations of all backgrounds began to segregate. High-income groups developed fewer cavities while low-income groups began to have more tooth decay. Today (2018) there is a remarkable difference in caries rates based on socio-economic status (SES). Many public health experts have identified low SES as the most important risk factor for caries. If this is in fact the case, then there must be very complex factors at work in this disease. We already have addressed the fact that caries is a multifactorial and multibacterial biofilm disease. We know that sugar is perhaps the most important player in this drama. Sugar enhanced foods is now a cheap commodity.

Populations who do not have access to processed sugars, simply do not develop caries. For sake of simplicity, if we set aside the role of a multispecies biofilm and look at the other factors that contribute to the disease, these have been characterized as the "social determinants of disease." Having been trained in microbiology, in the past it has been difficult for me to grasp the importance of the social determinants (SD). We have been forced to abandon the single pathogen disease model (Koch) and try to understand the complex multispecies ecological biofilm caries model (Marsh and Costerton). I have had a difficult time trying to calculate the role played by social determinants. It seemed rather naive and simplistic to say let's eliminate poverty in order to reduce tooth decay. At the same time, the challenges of facing social inequalities and moving people into health promoting environments, seemed well meaning but overwhelming to me.

An advertisement from a local grocery store promoting coca cola from Mexico because it has more sugar. Wow!

I felt more empowered, to work on "Finding "The Cure for Caries." Over time, it became clear to me that a caries vaccine was not on the horizon. The magic bullet for strep mutans was not going to do it. A complex multispecies biofilm is incredibly ***smart*** from the standpoint of evolutionary biology. The bacteria both compete and collaborate in an ever-changing milieu of the oral ecology. DNA is shared among bacterial species and gene expression is turned on and off in a dynamic dance with the environment.

The social determinants of caries as a human disease are equally complex. There may be genetic factors, which we do not understand that effect salivary function and other host protective factors. The introduction of high fructose corn syrup and its various commercial forms has appeared in every niche of human society. **It is now clear that sugar consumption is the number one cause of caries**. When sugar was rare and expensive, caries was a disease of the affluent. Today sugar enhanced products are inexpensive and available everywhere. Commercial interests in the form of highly processed fast food companies have reached out into even the most remote human habitats. Sugar has become cheap and plentiful.

I now believe that we need to tackle caries using a two-pronged strategy. We must defeat the multispecies biofilm pathogen using technology that has proven effective. At this juncture in time, that appears to be silver ion compounds in either combination with fluoride treatment protocols, or in a combined product (SDF), these are our best choices. We must implement efforts to both educate the public about healthy eating practices and preventive procedures like proper tooth brushing with a fluoridated toothpaste. Also, we must be advocates at the policy making level to control the expansion of the commercial sugar industry.

Attempting to treat tooth decay with only a restorative model is doomed for failure because the cause is ignored. Restoring all caries lesions does not remove bacteria from the oral environment. Bacteria replicate at very high rates in the mouth when provided with sufficient sugars and carbohydrates. Twice a year professional polishing of teeth may provide a better environment for an examination, however it does nothing to control a pathogenic biofilm that is able to return within hours. Additional therapeutic interventions are indicated.

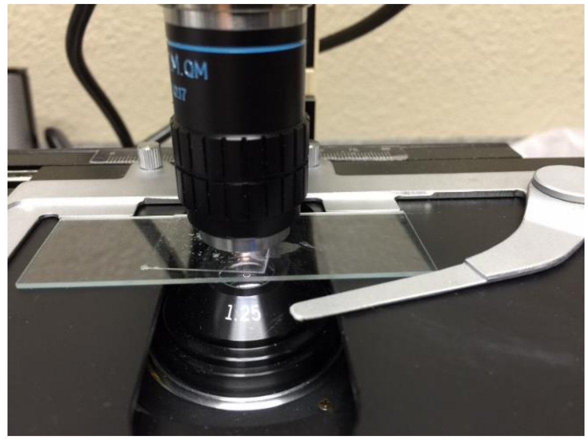
<u>We must implement programs that address both the high-level social determinants of disease and also reach down to the level of oral ecology simultaneously.</u>

Having been trained in microbiology before going to dental school, I find that I tend to cling to my microscope. Looking at oral bacteria under the microscope gives me great satisfaction, as if I can finally see the enemy. I wonder what G. V. Black and W. D. Miller thought as they also gazed through their microscopes more than one hundred years ago.

Video taken of live bacteria from plaque sample

- https://www.youtube.com/watch?v=hnnkECUJFh0

Perhaps Pogo, borrowing from Admiral Perry, was right in declaring, ***"We have seen the enemy and he is us".*** Now that the dream of a caries vaccine is a distant memory, we have to work with what we know. **SDF may possess vaccine - like properties**. Simply declaring that caries is a preventable disease and blaming the patient for not doing the right things, will not be successful,



we can do more. Now we understand that working as advocates to improve human living conditions, we can address the social determinants of this disease and therefore impact oral health as well.

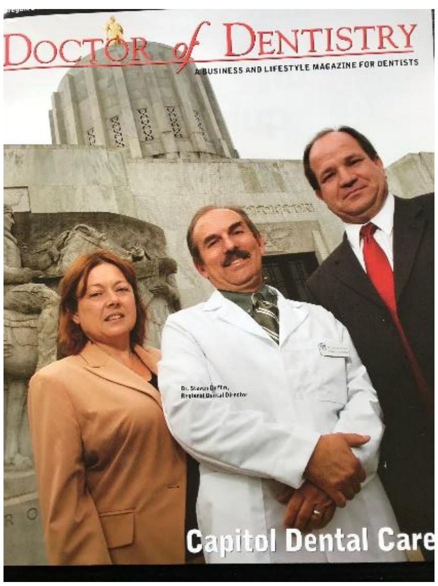
Economics of Medical Management of Caries

(Dr. Steve Duffin, DDS)

In a landmark text on healthcare transformation, <u>The Innovators Prescription</u>, by Harvard professor Clayton Christensen, a core element of the spiraling medical inflation problem is identified as the procedure-based fee-for-service reimbursement system, long in place in the United States. This creates upside-down incentives that result in over-spending in some populations and a lack of access to care in others. Clearly, the concept of coordination of care in some form or other, must be brought to bear on this problem.

In 2005, while working as the CEO and dental director of a large Medicaid managed dental care program in Oregon (Capitol Dental Care), I found myself searching for answers to both the clinical problems arising all around me, and the economic ones related to healthcare resource maldistribution. There had to be a shift of resources away from expensive surgical interventions and toward more effective preventive and disease management programs. I realized that if I was able to achieve my goal of a community of healthy patients, a business model based on procedural reimbursement would not be sustainable. Therefore, before I began this journey as a clinician, I established a business model that would reward myself if I actually was able to improve the health of my patients. Historically, large employers and government programs generally purchase a benefit plan from some third-party administrator such as a dental insurance company. The third-party is then responsible for paying provider claims based on encounters. The loss-risk which may occur from claims exceeding premium income, is managed via manipulation of coverage criteria, requirements for pre-authorizations etc. This byzantine system reinforces a lack of transparency between the three groups: payers, providers and patients. Healthcare providers who just want to practice medicine and dentistry are caught in this terrible vice grip between the agendas of payers and patients. Everyone is being manipulated by the third-party administrator organizations that maximize their profits by diverting resources away from treatment and the payment of claims. Having worked on both sides of this arena, I can attest to this dysfunctional system. In dentistry, we experience an amplification of this situation because of the misbelief that we can control infectious conditions such as caries and periodontal disease with surgical procedures. Furthermore, clinical providers are rarely given any training in the economics of healthcare delivery systems, management of adverse selection risk, and population- versus-individual healthcare programs. I wanted to be free of nonsensical limitations based on maximizing the profitability of some third-party payer. I knew that if I could be free to discover the optimal therapy based on individual needs, and apply that philosophy to each and every patient, I would be moving in the right direction. Then, over time, the oral health of my patient population would improve.

This required that I educate myself about the roles and responsibilities of all the various parties from the primary purchaser of services, the operational needs of running a dental practice, and then, to the expectations and needs of the patients themselves. There had to be a way to use existing resources more efficiently. I saw right away that the “drill and fill paradigm” had failed. I needed to move away from a surgical treatment model and toward a more evidence-based disease management patient care model. Since the bulk of the existing economic resources were tied directly to the surgical treatment paradigm, I knew that I had to choose a different economic path. As I thought through all of these competing forces, I decided to combine the role of the provider and third-party payer. My choice was to accept a capitation payment for an initial assignment of 2,500 Medicaid patients in an Oregon zip code with no dental providers. At first, it was like walking directly into a hurricane. The pent-up demand for dental services in my patient population kept me in the office long hours with emergencies waiting at the front door every morning, and after-hour calls every evening. Quickly all of my allocated hospital dates were filled and we had an operating room waiting list of six-plus months for children with severe cases of early childhood caries. Living in this whirlwind of activity placed a great deal of pressure on me, as a dental provider, to find different solutions to the problems that I was facing. The good news about having capitation income during this period was that I was able to support the economic needs of the clinic without wondering if I would need to do one more crown this month in order to fulfill pressing financial responsibilities. One of my early motivations to introduce silver nitrate into the practice for caries arrest, was to simply buy time to stabilize my current patient population before the development of life-threatening abscesses. My eyes were really opened to the power of the MMC protocol as I was doing cases that had been scheduled in the hospital, but pre-treated with silver nitrate three to six months earlier. The advanced caries had been arrested and tertiary dentin had formed in many teeth which had been previously treatment-planned for pulpotomies and stainless-steel crowns. I freely admit that my position as CEO and Dental Director of Capitol Dental Care in 2005 allowed me to establish this creative practice environment and business model.



Over the next several years I tried to share my enthusiasm with colleagues from the world of dental insurance and large group dental practice. This effort was received with little enthusiasm and despite my ability to demonstrate decreasing levels of disease in my patient population, my ten-year relationship with Capitol Dental Care ended badly. By good fortune, another large Medicaid plan in Oregon, Advantage Dental Care, was showing interest in the medical management of caries, MMC protocols. My assigned patients were able to switch plans and remain patients of my practice at Shoreview Dental. Our practice continues delivering the same philosophy of care with a blended economic reimbursement model based on capitation, as well as a fee for service component (2019). Over time, and as we have been successful in reducing the demand for expensive surgical procedures in our assigned population of patients, the economic health of our practice continues to grow. I would like to add in closing that capitation reimbursement will only work when the “law of large numbers” is in force. With a small number of capitated patients there is too much risk that a few individuals with high treatment needs will absorb the entire capitation revenue. Over time and with effective disease management programs such as MMC in place, this risk is mitigated. I do not recommend that any provider accept a capitation program with fewer than 1,000 enrollees. Consider the combination plans. These include a small capitation amount and a reduced fee for service component. I personally believe that these are the worst possible scenarios for the provider. The plan administrator keeps the bulk of the premium payment from the payer; passes a small capitation amount to the provider; and then, encourages them to make up the difference in a reduced fee for service practice environment. Often, the patient is responsible for the reduced fee -for-service component. Left only to collect a small monthly capitation payment, the dentist may then be pressured to perform excessive surgical procedures to generate additional practice revenues. The only entity which wins in this practice model is the dental plan which is able to keep the majority of the premium payment and push all of the risk of utilization back onto the provider who has to work like a squirrel running in a cage to keep the business alive.

Medical Management of Caries Policy

(Dr. Harris Contos, DMD, MBA)

Dr. Harris Contos and Dr. Steve Duffin at the Forsyth Institute, Boston.

The previous chapters in this book have amply demonstrated the clinical and cost- effectiveness and other considerable advantages– diminishment of "the fear factor" for children, in particular, but also applicability to adult populations– that SMART holds over traditional "drill and fill" dentistry in the treatment and prevention of tooth decay. This chapter will take a look at the implications of these attributes, in the wider health care context, how and where SMART fits into that, and what this implies for dental care in the future. The premise of this chapter is the following:

1. It is no exaggeration to say that SMART is a paradigm shift, a game changer, a disruptive technology, an example of "creative destruction"– whatever term one wishes to describe the discarding of a heretofore accepted orthodoxy, and its replacement with a new approach (or perhaps it's more accurate to say a "back to the future" reincarnation of silver nitrate, only updated).

2. The existing organization of dental care delivery is rife with economic inefficiencies and artificial barriers to care, politically buttressed to maintain economic advantage, with the dental health of the population being to a large extent only an incidental function of that. As such, the organization, financing, management, and measurement of dental care based on SMART principles will have as much if not more bearing on the dental health of the population than just the clinical advantages of SDF themselves.

3. Properly exploited and implemented, SMART-based dental care signifies effective control and meaningful reduction of caries, and possibly periodontal disease, in the population. Bringing about such a state of affairs will also signify, and necessitate, what will be a wrenching end for most in dentistry as it is traditionally known.

4. In place of that wrenching end will be a new construct to address the dental health needs of the nation, one that articulates well with the newly emerging agile,

accountable, competitive, and consumer-responsive health care environment.

There are “tectonic shifts” taking place in health care, more broadly outside of dentistry at the moment [that there is a bifurcation between dentistry and the rest of health care is a pertinent matter, but will not be dealt with at much length now], but they are beginning to be felt in dentistry as well. These tectonic shifts not only compel a look at evolving landscapes, to see where solid ground can be found upon which to lay durable foundations, they can also prompt analysis of the underlying “geology” to gain some explanation for the familiar ground underfoot now becoming so unstable. So before entering into the discussion on the emerging health care environment and dental care’s place in it, it bears taking a look at what has lain underneath dentistry for over a century and half now.

Inconvenient Issues

There are related issues that lie at the core of the way in which the disease of caries has been traditionally addressed: first, the full spectrum of society’s resources– from the scientific and etiologic understanding of dental disease, dental education and training, practice models (i.e. organization of the delivery of care), workforce composition, financing of care, evaluation of quality and appropriateness of care, are issues to be examined, and secondly, how that entire spectrum is organized, ostensibly to achieve the end result of good dental health [this applies to any of society’s undertakings, broadly speaking the organization and use of its resources to attain desired goals]. In this country, that “overall organization of dental care resources" is predominantly characterized by the solo, private, procedure-based, fee-for-service cottage industry model. For a disease regarded as essentially preventable, it needs to be asked how appropriate the existing organization of dental resources, again, everything from education to practice model to financing, and more, is to prevent the occurrence of disease, or once it has appeared, to halting its progression to loss of tooth structure, or loss of the tooth itself. The tools with which to do this at “tooth level” are community water fluoridation, fluoridated toothpastes (and hence oral hygiene habits), sealants, fluoride varnishes, and lately, returned to the scene, silver nitrate in its modern formulation, SDF. A paradox arises. None of these requires the services of a dentist, provided in the traditional dental office setting. This then prompts the first “Inconvenient Question”:

What Does a Dentist Do?

The answer is that the dentist largely allocates his or her time, labor, and capital to the repair, restoration, and preservation of once-diseased tooth structures, or to compensate for entirely lost tooth structure through prostheses and, again, more recently, implants. In other words, the dentist spends his or her time, and deriving his or her income, correcting for and accommodating failed prevention, the more involved and intricate the procedure the higher the income. Prevention in the form of community water fluoridation is achieved literally outside the dentist office, and varnishes and sealants are provided by the dental hygienist or other suitable trained personnel, although again there is no reason why these preventatives need to be restricted largely to the traditional dental office setting. Thus, at a very fundamental level, the organization, financing, and management of dental care resources is heavily weighted to costly reparative procedures, and is thus wildly mismatched to timely, effective preventive measures. Dentists’ skills and the existing organization of care in which they practice might be given some credit for reducing the progression of disease to edentulism (e.g., tertiary preventive treatment of pulpally involved teeth with endodontics, and mechanical removal of decayed tooth structure followed by restoration of structure with artificial materials of one form or another, such as gold, composites, or ceramics, however costly); they cannot be much credited for preventing the inception or early minimization of disease (primary and secondary prevention, respectively). In still other words, the thrust of virtually the entire aggregation of dental resources, in direct services alone, approximately 150 billion USD in annual national health expenditures, for those who are able to avail themselves to care, is to create, support, and perpetuate a highly technical and intricate, skills-dependent, procedures-based, and costly reparative conception of how to treat caries, predominantly through removal then replacement of tooth structure, in private, solo, fee-for-service practices. Apart from being an arrangement wholly inappropriate to the prevention of disease, it is a "system" of presumed but of largely indeterminate quality and appropriateness of care along cosmetic, technical, and functional lines; weak cost control; high out-of-pocket expense for consumers; a tightly circumscribed, limiting, hierarchical workforce structure; widely uneven access; underdeveloped performance and outcome measures; primordial economic analysis and health services research; absence of innovation in organization and financing; poor integration into the rest of medicine; little accountability; and a general lack of understanding and ability to respond to the demands of health reform. The weighting of resources, indeed even the default thinking toward repair of one degree or another after decay has set in, versus prevention, prompts a second “Inconvenient Question” related to “What does a dentist do?”

What Does Access to Dental Care Mean?

The answer is that under the present organization of dental care, access means lowering or overcoming the financial, geographic, socioeconomic, other barriers to what is at its core a reparative orientation centering upon the skills of a dentist, rendered in the private, solo, fee-for-service setting, while relegating preventive measures– again, none of which require those skills or settings– to a distinctly secondary emphasis. This has been the implicit viewpoint in dental health policy for decades and illustrates a fundamental paradox– the organization of care focused on ex post facto treatment of disease is looked upon as the model with which to deliver prevention, although it has little capacity to do so on an organizational, financial, managerial, or accountability basis, or it must be said, on even a conceptual basis. Where along the spectrum of caries progression from sound, non-diseased tooth surface to early demineralization to active decay in the enamel to penetration to dentin to involvement of the pulp to possible extraction of the tooth does “access to dental care” apply? If at the point of primary or early secondary prevention, then neither the skills of a dentist nor the traditional practice setting are required, illustrating but one economic inefficiency, and indeed could even be highly inappropriate as artificial barrier to care; if at the point of tertiary prevention (or later) involving the costly technical skills and intricate procedures performed by a dentist, then the very notion of preventing tooth decay is largely negated and rendered irrelevant.

In other words, the way dentistry is understood, taught, practiced, delivered, and paid for assumes that tooth decay and tooth loss are more inevitable than preventable.

Come Health Reform

Decades of largely uncontrolled health care costs with little in the way of consummate improvement in health status (the United States spends far more on a per capita basis than do comparable societies yet ranks 17th in health status worldwide) has been one impetus behind health reform as seen in the Affordable Care Act (ACA). Of the several terms and concepts used to describe health reform, two central and related ones are these, "value over volume" and "better, smarter, healthier care." The former essentially calls for getting more for the health care dollar by looking upon health as other than the summation of all procedures that can be rendered. The latter further underpins the notion of value by separating effective from non-effective care ("better care"), spending the health care dollar on timely, effective, less costly interventions, which not even include medical treatment ("smarter care"), all of which are intended to lead to demonstrable improvement in health status for the population and patient care experience for the individual ("healthier care"). Achieving these ends extends to other dimensions of health reform, involving integration and comprehensiveness of care with emphasis on primary care; the development of new delivery of care models; and the migration away from fee-for-service reimbursement to various "alternative payment models" (APMs) (e.g., global budgets, bundled payments, risk-sharing and shared-savings arrangements) tied to meeting quality and accountability goals, sometimes succinctly referred to as "no outcome, no income." The organizational idea to achieve this is the "accountable care organization" (ACO), briefly described as a network of doctors and hospitals that shares financial and medical responsibility to provide the right care at the right time for beneficiaries so as to avoid unnecessary and more costly care resulting from declining health status. Logically, this involves primary care, with a primary care physician and team at the heart of each patient's care.

A further tool, a more conceptual one, needs to be mentioned, which ties in with the rest: the emphasis on the competitive (versus, for example, the regulatory or the utility) model in the health care marketplace. The argument, the theory, is that better overall outcomes at better overall prices will result when sufficiently informed consumers (e.g., individuals, employer health benefit plans, state (Medicaid) and local governments) on the "demand side" of the market make the decisions on where to spend their health care dollars based upon transparency in prices and outcomes among providers (e.g., physicians, health care systems, newly emerging non-traditional delivery models) comprising the "supply side" of the market. Presumably, those who succeed in the marketplace will be those with the most astute organization, financing, management, and performance measures, which comes back to those concepts of "value over volume" and "better, smarter, healthier care." To what extent a reasonably functioning competitive health care marketplace can take shape remains to be seen– the conceptual hurdles are great, and thus far results are indeterminate to disappointing– but recent innovations and experience with new supplier entrants into the market also indicate there is considerable potential to be realized in transforming health care in this country.

Dentistry and Health Reform

How, even whether, dentistry as presently organized– again, essentially centered upon costly, technically intricate procedures for failed prevention– can respond coherently, meaningfully, effectively to the imperatives of health reform and the contours of a competitive health care market is doubtful. Succinctly, in all dimensions concerning the disease of tooth decay, dentistry's tradition has been one of staidness. Compounding this situation is the place dentistry has within the ACA, a matter which is further reflective of dentistry's historical separation from medicine in delivery of care, but particularly with regard to payment methods. Whereas medicine has seen a number of systems such as DRGs, prepaid capitation, prospective payment, and now more recently under health reform various alternative payment systems– all arising from the leverage of Medicare as the dominant payer in health care– dentistry adheres to a spare insurance model for those who have it (which really is not insurance at all as it violates the tenets of insurability, and is more aptly described as a subsidy mechanism) and is the one branch of medicine which has the highest out-of-pocket expense for the patient of them all, which in itself can be a major barrier to patients seeking care. In other words, dentistry has largely been shielded and immune from the developments taking place in health care beginning over 50 years ago with the greater involvement of the Federal taxpayer dollars with the enactment of Medicare.

Apart from payment systems, the dental health provisions in the ACA, with one exception to be discussed later, reflect reform only in the sense that dental care is at all included in major national health legislation. In all other regards, these provisions are essentially inconsequential add-ons to the intentions of health reform, devoid of the incentives and imperatives to achieve "value over volume," and essentially regarding the existing private, solo, fee-for-service, reparative concept of dental care as the standard, even immutable, organizational model for dental care. There are two major problems with this. The first is that where dental health is mentioned– such as in school-based clinics, workforce development, addressing underserved populations, expansion of Medicaid– it all amounts to grafting various measures onto the existing practice model of care. It is "in the box" thinking. This was discussed above, for a disease which has been termed preventable, dentistry is instead organized to be reparative, with little capacity to be effectively and efficiently preventive. All that the ACA dental health provisions do is to incorporate and extend an organizational model that is inappropriate to the nature of the disease. In a somewhat strained but not entirely irrelevant analogy, the scope and momentum of health reform under the ACA– again, addressing organization, financing, management, and accountability– are to dentistry what transportation using autonomous driving is to auto body repair shops. Manufacturers (providers) are hastening not only to design vehicles for this new paradigm of travel by automobile (e.g., no need for steering wheels or pedals, vehicles communicating with one another and their immediate environment), but also to develop and implement the engineering and software technologies for incorporation into a larger, integrated transportation system, a whole new way of moving large numbers of people with vastly greater safety and efficiency– and perhaps with greater equity– versus reshaping and replacing bent metal at auto body shops resulting from countless collisions inherent to the existing, more or less "free-for-all" system of travel by automobile.

The second major problem concerns the emphasis of the ACA on comprehensive primary, preventive care, and on integrated, coordinated care. Contrary to expectation, the references to primary care in the ACA do not include dental health, and with regard to integration and coordination of care, there are no stipulations for dental care to be included in such organizational arrangements such as ACOs, another instance where dental care remains an entity apart from the rest of health care. In part, this stems from the historical separation of medicine and dental care extending back to the 19th century, but of more recent history it centers upon the exclusion of dentistry from Medicare coverage beginning in 1965, whether through political lobbying and maneuvering on the part of "organized dentistry" or the slighting of dentistry by policy makers at the time, or both. Whatever the reasons, both conceptually and programmatically, dental care remains outside the central tenets of health reform– again, "value over volume," "better, smarter, healthier care"– operating largely along its own dictates, and this itself represents a policy failing in health reform.

The one provision in the ACA which could have seen dentistry come more into the fold of health reform is Sec. 5304, "Alternative dental health care providers demonstration project," authorizing grants to 15 eligible entities to establish programs to train or employ "alternative dental health care providers," including "community dental health coordinators, advance practice dental hygienists, independent dental hygienists, supervised dental hygienists, primary care physicians, dental therapists, dental health aides, and any other health professional that the Secretary determines appropriate." The amount of each grant was to be "not less than $4,000,000 for the 5-year period" during which the demonstration project was being conducted, total $60 million. Come time for the actual funding of what the act authorized, and the lobbyists for so-called "organized dentistry" saw to it that the funding was eliminated when it came time for the actual appropriations in Congress.

Of course, such an attitude toward workforce development and other potential delivery models stemming the reform is nothing new to the dental profession. "Project Rotunda" at the Forsyth Dental Center in Boston, described in The Forsyth Experiment: An Alternative System for Dental Care, presaged Sec. 5304 by "evaluating the results of giving a well-established category of auxiliaries– dental hygienists– the relatively brief extra training necessary to perform routine procedures that tradition holds should be executed exclusively by dentists. These delegated duties include the two basic phases of restorative dentistry– drilling and filling cavities in decayed teeth– as well as administering local anesthetic injections." Itself presaged by an auxiliary training experiment initiated with a federal grant at Forsyth in 1949 which was swiftly halted by professional misinterpretation and opposition, and even further back by the example of the New Zealand "dental nurses" program successfully inaugurated in 1921, "Rotunda" was launched in March of 1972, demonstrated its practice model "of improved cost effectiveness with no loss of quality in auxiliary-rendered restorative dental services," and was terminated in June of 1974 "under pressure of an opinion from the attorney general of the Commonwealth stimulated by the board of dental examiners."

More recently the familiar theme played out with the Alaska Native Tribal Health Consortium, which introduced the first successful dental therapist workforce in the United States in 2004, built again upon the dental therapist education and training program in New Zealand in existence since the 1920s. Opposition by the American Dental Association went so far as to bring suit against individual graduates of the dental therapy program, the legal action failing for, among other reasons, having no standing over the sovereign native tribes.

There are at least three things to be derived from this: 1) that the evidence is long established that suitably trained non-dentist personnel can be trained to provide quality restorative care; 2) that the failure to implement widely the lessons of New Zealand, Forsyth, and Alaska represents an artificial barrier to new entrants into the dental care market and restricting access to care, so that the status quo of organized dentistry can continue to enjoy economic rents (i.e. unwarranted profits over what an efficient market would provide); and 3) organized dentistry has defended its position and exerted its influence through exercise of political influence and stratagems rather than through flexibility and adaptability in the delivery of care to meet consumer demand, which comes at higher prices, or goes unmet.

But there is a caveat in the formulation of dental health policy based solely on what the New Zealand, Forsyth, and Alaska programs have demonstrated: as effective and as rational and as sensible as these workforce developments have shown to be, they are not in and of themselves sufficient to address the demands called for in health reform. In part, this is because they are workforce models still centered upon the procedure-based, "drill and fill" model of restorative treatment. To underscore a point, complementary and requisite changes in the organization, financing, and management of care go unaddressed with this narrow focus, particularly as they relate to emphasis on primary and secondary prevention in dental care.

Achieving value over volume cannot be done through the existing models of medical or dental care (to the extent there even should be a distinction between the two), as mentioned previously this will require cutting across several dimensions. But one example of the intersection and interplay of two of these dimensions can be found in alternative payment mechanisms, and innovations in the delivery of care. One leads to the other. The importance of innovation in health care reform is seen in the establishment of the Center for Medicare and Medicaid Innovation within the Center for Medicare and Medicaid Services (CMS), the purpose of which is to provide incentive for experiments in new forms of care delivery and disease treatment in fulfillment of the "triple aim" of better, smarter, healthier care. The fundamental tenet of the Center for Innovation is that providers share in the savings in money Medicare and Medicaid otherwise would have spent under a traditional fee-for-service arrangement if they can develop care models that meet savings and quality objectives. With initial focus on such conditions as diabetes management, obesity, and blood pressure control, the so-called "low hanging fruit" to avoid costly in-hospital care, there has been success in addressing these conditions, largely through care models based on early intervention, preventive care, and patient-provider engagement to promote better compliance to medication and exercise, diet, and other behavioral regimens.

These approaches are based on organizational models utilizing an array of non-physician personnel, e.g., nurse practitioners, physician assistants, physical therapists, nutrition counselors, pharmacists, home health aides and such, using data for continuous tracking of patient health status and early warning of any decline. In other words, a multidimensional integrated and coordinated approach– in essence, a flexible and responsive team– is used to improve and maintain health status, and to avoid more costly medical treatment, particularly in-hospital. The individual patient benefits through better health status; the care-providing organization benefits from sharing in the savings in avoiding more costly care; and society benefits similarly with a better functioning individual and the avoidance of considerable costs for what is often crisis care. This more comprehensive approach to the patient with one or a combination of these conditions has proven far more successful and effective than solely repeated visits to the physician's office for episodic care.

The message should not be lost here with regard to dental care– new care arrangements involving a cast of non-physician providers, in new forms of care delivery, to intervene early, to provide necessary assessment and monitoring of the patient's condition, and to provide measurable indicators of the patient's status, are just as applicable in dental care as in the rest of medicine. As with the multidimensional organizational approach to keep the diabetic from going into crisis, it is only logical to think there would be a dental analog. To some extent, there is, with Caries Management by Risk Assessment (CAMBRA), described in further detail elsewhere in this volume. But even here, the right care at the right time for addressing tooth decay– and the example could well extend to periodontal disease– is hampered by its limitation to a traditional dental practice setting when, just as with much diabetic care and intervention, which can be accomplished in other settings, including the patient's home. And the very salient point needs to be kept in mind, just as with the other preventive measures of community water fluoridation, sealants, and fluoride varnishes, CAMBRA does not require a dentist for implementation. CAMBRA is the right conceptual approach, limited in its potential by staid, hidebound organizational thinking.

The trouble is that once again with dentistry being "out of the loop" on health care developments over the decades, particularly with regard to inclusion in Medicare, little such impetus for innovation exists. Little in the way of innovation emanates from commercial dental insurance either, which essentially sells basic coverage of an uninsurable product and then uses various negotiated fee arrangements for marginally lower prices on "big ticket" items, all within the framework of the predominant private, solo, fee-for-service cottage industry. There is no motivation or incentive for prevention, measurement of quality, assessment of outcomes. It is about as pure an example of "volume over value" as one can find in health care. Dentistry simply does not possess the workforce nor the attending organizational, financial, managerial, and accountability capacities to utilize that workforce to peak advantage for the early interception of disease. Of course, this situation is mostly due to restrictive state dental practice laws, either limiting what dental auxiliary personnel can do, or where they can do it, e.g., limited independent practice of hygienists, but this is a familiar litany, as seen for example with the Forsyth and Alaska native experiences.

An additional failing in this is that comprehensiveness and integration of care also suffer, as there is neither the recognition of the importance of dental care in the above-mentioned innovation models, nor the capacity for dentistry adequately to enter into them. Not only to do the fundamental organizational tools simply not exist, the conceptual outlook itself on how to look upon dental health is absent as well.

An example is illustrative: this author attended a conference a few years back called "The Philadelphia Story: Transforming Health Care" in which three top executives (two being MDs, one an RN-PhD) from Philadelphia-area health care systems related their challenges and experiences in transforming their business and care delivery models to a "value-based" orientation, including making primary preventive care a reality. Come the question and answer period, I asked the following question: "given the emphasis on comprehensive, primary, preventive care in the ACA, could you tell us where dental care stands in your business plans?" This was not meant to gig anyone, but rather to ask the straightforward question just how comprehensive "comprehensive" care really is. After a while to digest the question, one of the executives responded, quite candidly and honestly, "I don't even think about dental." A second panelist then responded, "I think once we figure out the blocking and tackling facing us now, then we can move on to the other issues like dental and mental health care." Both were direct, honest, concise, forthright responses, which spoke volumes about the separation of dental care and medical care, about dentistry's place (or lack thereof) in health reform, about the integration and comprehensiveness of care (again, or lack thereof) in health care systems.

A further point needs to be added: these executives and their counterparts elsewhere are attempting to steer their organizations through the use of collaboration, operational strategies, technology, and management information to achieve financial and clinical outcomes in a value-based health care environment where they are also at financial risk for failure to perform. Aside from the historic chasm between medicine and dentistry, it is understandable why these executives would be reluctant to include dentistry in their business plans, where little in the way of the challenges they face, and the strategies they have to address them, are understood. Including dental care as it currently exists presents more a risk and potential liability than it does any benefit, regardless of the emphasis placed on comprehensive and integrated care.

Other Changes in the Health Care Environment

Changes are taking place to reconfigure heath care outside the direct influence of Medicare (and Medicaid) to shape new payment models and to spur innovation. In line with the "competitive model" of health reform, heretofore peripheral or wholly non-health care related entities are entering the health care marketplace, one significant example of this being the emergence of retail clinics by CVS, Walgreens, Rite-Aid and others, but also by the likes of Wal-Mart. More recently, Amazon, Berkshire Hathaway, and JPMorgan Chase have announced plans to create a new healthcare company aimed at cutting costs and improving services for their employees. In the former case, these businesses see opportunity in pursuing the primary care market; in the latter case, frustration at not seeing value in the prices they pay for employee health benefits is prompting these giants in their respective industries to apply their considerable financial clout and business acumen to shape a better health care system providing "better, smarter, healthier" care for their employees. Both of these developments fall into the "market disruptor" category.

A number of features need to be noted about the retail clinics:

- Their locations and hours of operation greatly expand access to care. In contrast, appointments usually have to be made to see the dentist, at his or her locale.

- Their business model is based upon non-physician personnel such as nurse practitioners, but also physician assistants and, increasingly, pharmacists practicing "to the maximum of their licensure." In other words, artificial barriers to providing care are lowered or eliminated so that the most potential can be derived from these non-physician personnel. The previous points on traditional dentistry's attitude toward analogous dental personnel stands in contrast.

- Consumer satisfaction and quality of care have ranked as high or higher than with traditional doctor office visits. This parallels the experience with the Alaska Native dental therapy program.

- Consumers have also reacted positively to transparency in pricing, although the complexity of health insurance coverage makes complete final cost impossible to calculate uniformly. Nonetheless, patients stand to get better, more easily available pricing information at retail clinics than at physician and dentist offices.

- Once seen as a competitive threat to traditional sites of ambulatory care delivery (e.g., doctors' offices, hospital emergency rooms), some retail clinics are now forming affiliations with larger health systems, in a mutually beneficial arrangement. Retail clinics can have formalized protocols with which to refer patients in need of referral to further care, and the larger health system can look upon the retail clinic as a conduit for patients, as well as a venue in which to situate some chronic care management (e.g., diabetes, hypertension), a role retail clinics are increasingly involved in, the advantage of access both in terms of location and hours being particularly advantageous. All parties stand to benefit: patients with easier access to quality, integrated care, perhaps at lower cost; the retail clinic by gaining a new patient and the resources of the larger health system; and the health system also by gaining a new patient, able to be followed in a lower-cost setting. There is integration of care, and a wider team involved in providing it.

Briefly, this is the outline of the messages to be seen as health care in this country evolves:

- New entrants are coming on to the health care field;

- Primary care is being given new emphasis;

- More rational, efficient, and effective use is being made of non-physician personnel;

- Innovations in payment and delivery of care models are spurring ways in which to achieve "value over volume" and "better, smarter, healthier care";

- New multi-dimensional, multi-tiered approaches are being used to address disease before it reaches crisis stage;

- New affiliations and collaborations are leading to more sophisticated, integrated organizations and networks of care;

- The dynamics of a working competitive marketplace are beginning to manifest themselves, with suppliers being more attuned to consumer and payer (principally, Medicare and Medicaid, but also commercial insurers) demand for better pricing and quality, and consumers being better able, through increased transparency as well as having more options open to them, how and where to spend their health care dollars.

These are the messages to be gleaned, and these are also the opportunities to be capitalized upon, for a health care organization to have a place in and to succeed in this health care environment.

What this means for dentistry is portentous. Traditional dentistry as it has been practiced for over a century is simply incompatible with and incapable of performing in this new environment, for reasons listed above, at the core centering upon its procedure-based “volume over value” underpinnings ex post facto of disease setting in.

On the other hand, SMART-base dentistry is ideally suited to exploit fully this new environment:

- SDF and GIC are remarkably cheap and easy to apply;
- The patient experience of treatment with SDF is a complete reversal from the “fear of drills and needles” of traditional dentistry, meaning patients are more likely to seek care.
- SDF and GIC do not require the skills of a dentist, in a traditional dental office, to apply. The previous examples from New Zealand, Forsyth, Alaska, as well as Dr. Duffin in Africa and South America have amply demonstrated this, and there is no reason why these same skills cannot be incorporated into the education and training of nurses, nurse practitioners, physician assistants, and other ancillary personnel.
- The ease and simplicity of SDF application, and its ready acceptance by patients, all coupled with the emergence of retail clinics means that access to care and early intervention (i.e. primary and early secondary care) increases severalfold.
- Access is vastly increased for populations otherwise unable to seek care, i.e. SDF can be applied by a mobile dental team (or nurse practitioner or other) tending to the elderly, the bedridden, the immobile in whatever location they are.
- Out-of-pocket expense virtually disappears as a barrier to care.
- A simple metric exists by which to judge effectiveness and quality of care– arrest of decay. As SMART provides for the saving of tooth structure versus its removal and then restoration, the technical aspects of what constitutes a good filling or crown becomes largely irrelevant.
- All the advantages of SMART-based care make its being a part of larger, integrated health systems attractive as a way to attract patients not only for dental care, but as a conduit for comprehensive care as well.

The SMART Dental Care Organization (SDCO)

Difficult as it be even for adherents of SMART-based dental care to realize and accept, deriving SMART’s full potential to address broadly the disease of tooth decay, and not just a focus on its clinical aspects, means the traditional dental practice– meaning not just its individual site location, with so many operatories and auxiliary clinical and administrative personnel, headed by a dentist, and the conventional payment and reimbursement methods that go along with that– will come to an end. The reasons for this come down to two central ones:

- It makes no economic sense for a dentist to spend his or her time doing what can be done by a suitably trained non-dentist.

- A conventional dental practice cannot be economically sustained through the conventional payment method of billing by insurance code.

Smart SMART dentists, or smart non-dentist SMART entrepreneurs market disruptors such as the retail clinic operators, will recognize the fundamental economic realities of SDF, and act accordingly to shape the SDCO of the future:

- The fundamental operating unit will be the non-dentist workforce applying SDF and GIC.

- In place of the traditional dental office will be a widespread network of various sites where SMART-based care is provided, such as retail clinics, pediatrician's offices, school-based clinics, long-term care facilities.

- Borrowing from the example of the Alaska Native dental therapists, these locales will be data-linked with networked dentists for clinical support and referral if and when needed.

- Suitable patient and treatment data are collected at all encounters for clinical, quality, outcomes, and health services research purposes, all geared toward evaluating accountability.

- The SDCO is either an integral part of or closely affiliated with a larger health care system so that integration with medical care is seamless and efficiently achieved, and comprehensiveness of care attained.

- Payment will come in two forms: direct out-of-pocket from individuals, which will be of little if any burden given the low cost of SDF; and capitation under contracted arrangements with large employee groups, unions, state and local governments, Medicare plans, and state dental Medicaid programs, all basing their decision for dental care for their beneficiaries on the transparency in pricing and quality of the SDCO.

- The keys to success of the SDCO is to gain volume control of the market, so that over time it derives the bulk of its income from capitation of a large patient population which has minimal decay due to early interception with SDF. It is not an exaggeration to say that the SDCO would still get paid from having to do nothing.

- Not only the SDCO benefits from this way of organizing, financing, managing, and evaluating dental care. Society benefits as well by having the disease of tooth decay halted in its early stages, with the costly sequela of progressive disease being avoided.

This is what is entailed in addressing the disease of tooth decay. This is what is meant by health reform in the dental health context.

Section Five: Future Implications

The Path's Next Steps

(Dr. Aronita Rosenblatt, DDS, MSc, PhD)

It is with great pleasure that I (SD) introduce to the reader Professor Aronita Rosenblatt. I believe that Dr. Rosenblatt has presented her perspectives and vision into the social order of the future, intended for reader consideration. I first became aware of her work when I read the seminal paper Is Silver Diamine Fluoride a Silver Bullet for Caries, in which she is the first author. (*Rosenblatt, Stamford & Niederman, 2009*)
-Dr. Steve Duffin

The Future

"The future will be much simpler than the past. The past is the problem. In the XXI century there will be a wide range of access solutions for the problems of the Humankind. The new economy, based on happiness rather than in the Stock Market, will result in joy, different from the Old Economy, which resulted in life disparities. People will not have diseases because there will be free access to ways of keeping healthy. In this new century, the ministry of happiness will replace the Ministry of economics." (*Prado, 2017*)

Historical Facts

It all started with the Declaration of Alma-Ata, International Conference on Primary Health Care, Alma-Ata, USSR, 6-22 September 1978; the Conference strongly reaffirmed that health, a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity, is a fundamental human right.

The attainment of the highest possible level of health is a most important worldwide social goal, and that requires the action of many other social and economic sectors in addition to the health sector.

The economic and social development, based on a New International Economic Order, is of great importance to the fullest attainment of health for all and to the reduction of the gap between the health status of the developing and developed countries. The promotion of health of the people is essential to sustain economic and social development and contributes to a better quality of life and world peace.

The specific item addressed in this conference was primary health care, providing preventive, curative and rehabilitative services, health education, methods of promotion of food supply and proper nutrition.

The simplest but the most relevant point refers to the adequate supply of safe water and basic sanitation; maternal and child health care, including family planning; immunization against the major infectious diseases; prevention and control of locally endemic diseases; appropriate treatment of common diseases and injuries; and provision of essential drugs (*International Conference on Primary Health Care, 1978*).

Addressing Preterm Birth, Low Birth Weight, and Their Outcomes

Brazil is one of the 62 countries that achieved the goal of reducing child mortality, set by the United Nations (UN), through the Millennium Goals. From 1990 to 2015, Brazil decreased infant mortality by 73% (*Pesquisa do IBGE indica que mortalidade infantil permanece em queda, 2016*). The delivery of safe water supply and basic sanitation highly contributed to the results as mentioned earlier and in addition, children became healthier and with a reduced caries prevalence.

There is currently no definitive way to prevent preterm birth, the second-most common cause of infant mortality in the world. Reasons can include a mother's chronic health condition or poor nutrition. Adequate prenatal care is essential to ensuring that full-term infants are born at a healthy weight.

Studies suggest that infants born at low birth weight are at increased risk of certain adult health problems, such as diabetes, high blood pressure, heart disease to include dental conditions such as enamel and dentine defects, which facilitates the adhesion and colonization of cariogenic bacteria in poorly calcified dental tissue. The current literature indicates that there is a strong association between enamel defects, prematurity, and low birth weight (*Ribeiro, Oliveira, & Rosenblatt, 2005*) (*Oliveira, Chaves, & Rosenblatt, 2006*) (*Targino et al., 2010*).

Common Risk Factors and Determinants of Chronic Diseases

The common risk factor approach for integrating oral health into general health improvement strategies has been reported (*dos Santos Junior et al., 2014*) (*Sheiham & Watt, 2000*). The authors suggest that there are broadly shared social determinants of chronic diseases, such as diet, hygiene, smoking, alcohol use, stress, and trauma, that contribute to diabetes, heart diseases, cancer, dental caries and periodontal disease.

Addressing Untreated Dental Cavities in Children

Dental caries remains a relevant public health problem, and according to the World Health Organization (WHO), the disease affects about 60–90% of schoolchildren worldwide (*Watt & Sheiham, 2012*).

The United States National Health and Nutrition Examination Survey, 1999–2004, reported that the prevalence of untreated decay in primary teeth among children 6–11 years of age was 51% (*National Institute of Dental and Craniofacial Research, n.d.*).

In Brazil, the results of the last oral health survey indicated that 50% of children at five years old have untreated decay (*Petersen & Ogawa, 2016*). **Therefore, there is a need to establish school-based programs aiming to implement methods of arresting tooth decay in children who lack access to restorative dental treatment.**

Restoring Deciduous Teeth

Importantly, the deciduous teeth have higher permeability, lower bond strength to dental adhesive materials and lower surface microhardness than the permanent teeth (*Brazil Ministry of Health, 2012*). The size of the hydroxyapatite, when compared with the permanent dentition, plays an important role in lowering the acid resistance of temporary teeth (*De Menezes Oliveira et al., 2009*). In addition, the aprismatic layer of the deciduous enamel is thicker, more uniform than the prismatic area and more porous than the permanent teeth (*Fava et al., 1997*).

Thus, the features as mentioned earlier of the temporary teeth make them more susceptible to caries and challenging to restore.

Dr. Michael Buonocore, in 1955, changed dentistry from being mere `Drills, Fills and Bills (*Low, Duraman, & Mahmood, 2008*), by publishing his new technique for increasing the adhesion of dental acrylic resin to enamel surface. Therefore, from his first published work, he developed others that revealed the rate of dissolution of enamel and dentin in acid, and he found that the acid treated tooth adhered to the resin for 160 hours and to the untreated tooth, resin remained in place for only 6 hours (*Silverstone, 1970*) (*Badu & Joseph, 2005*).

However, as aforementioned, the thick aprismatic layer of enamel in the temporary teeth is still a limitation of the resin-bonded restorations for pediatric dentistry; marginal linkage and poor surface integrity remain a problem for this type of restorative treatment.

The Role of Fluoride Releasing Materials in Arresting Decay

Are fluoride releasing dental materials clinically effective on caries control? A systematic review of the literature indicates that the anticaries effect of materials that release fluoride don´t have clinical evidence (Sperber & Buonocore, 1963).

The Role of Silver Diamine Fluoride in Arresting Dental Decay (SDF)

SDF is a caries agent that has proven to be effective in preventing and arresting dental caries. The treatment does not require a traditional clinical setting; moreover, it is painless, easy to apply and noninvasive (*Buonocore, 1961*). In addition, it is suitable for outreach patients, with limited access to treatment. Systematic reviews reported on the efficacy of SDF at 38% in arresting dental cavities (*Cury, de Oliveira, dos Santos, & Tenuta, 2016*).

Recently, in the United States, the Food and Drug Administration (FDA) cleared SDF for use as a tooth desensitizer for adults over 21. However, dentists are increasingly using it to halt caries in children (*Horst et al., 2016*) (*Wambier et al., 2002*) (*Coutinho, 2002*). Countries like Japan, Australia, Argentina, and Brazil have been using this (SDF) solution for arresting caries in children for over three decades.

In developed countries, non-cooperative children can have dental treatment under conscious sedation or in an operating room under general anesthesia, which increases the risks and costs of the procedure. However, if parents could opt for a less invasive treatment, they would often choose SDF (*Collina et al., 2000*).

Silver Diamine Fluoride has been used to arrest and prevent caries with a high rate of success, easy application and low cost since 1960 (*Medeiros et al., 1998*). It is ideal for caries control in community-based programs in poor populations with no access to dental care. However, its use may cause the staining of the carious dental tissue (*Andrade et al., 1992*).

The Role of Nano Silver Fluoride in Arresting Dental Decay

Nano Silver Fluoride® 400NSF is a silver nanoparticle product, with chitosan and fluoride that arrests and prevents carious lesions, with no toxicity (*Pinto et al., 1987*).

Clinically, NSDF proved to be effective to halt caries in enamel and dentin without staining the teeth (*Wambier & Bosco, 1995*).

In this context, silver nanoparticles (AgNPs) are emerging, as an excellent alternative to add an antibacterial effect to dental tissues, with low toxicity and effective antibacterial action in the oral biofilm bacteria, such as Streptococcus mutans and Lactobacillus. Nano silver particles are capable of penetrating into the bacterial cell wall, preventing the DNA replication and the action of respiratory proteins (*Rosenblatt, Stamford & Niederman, 2009*).

Therefore, the treatment with NSDF is also simple, noninvasive and low cost. This new anticaries agent is ideal for disadvantaged communities of developing counties. This treatment may increase access to dental care Presently, higher concentrations of NSDF proved to be nontoxic (*Gao et al., 2016*), and clinical trials comparing NSDF 400 to NSDF 600 indicated that the more concentrated formulation is more effective in arresting tooth decay.

The Role of Fluoride in the Twentieth Century

The 20th century was marked by the discovery of the preventive possibilities of fluoride. The widespread use throughout the world benefited millions of people by ridding them of caries or by reducing the severity of this disease (*The New York Times, 2016*).

However, the continuity of its use in public health actions requires increasingly accurate health surveillance measures, without which there is a risk of iatrogenic production of dental fluorosis at unacceptable levels (*American Dental Association, 2018*).

Nevertheless, there is no reason to fear fluoride; its safety when used appropriately is well proven (*Food and Drug Administration, 2014*).

Despite so many benefits of fluoride products in the prevention of dental caries, there remain, among others, some questions: what will be applications of fluoride in the 21st century? Will fluoride-containing products continue to play a central role in coping with caries? What will be the new technologies?

From the Current Worldview and Into a Brightr Future

Over the last 15-20 years, in the developed countries, there was an overall decline in prevalence and severity of caries in the child population. Nevertheless, there was an increasingly skewed distribution, with the most disease now found in a small number of children, a critical polarization process, in which 70% to 80% of the carious lesions affect 20% to 30% of the individuals (*Promoting the oral health of children : Theory and practice., 2014*).

Disparities in oral health status remain for some population subgroups, such as the poor and members of racial and ethnic minority groups (*Crystal et al., 2017*).

Tooth decay is one of the most common chronic diseases among American children with one of four children living below the federal poverty level experiencing untreated tooth decay (*Yamaga et al., 1972*).

Still, the number of children with untreated decay, in the world, is very high; it happens mainly in selected geographic areas where the incidence of infants who are born prematurely and low birth weight is significant; mostly in children born to adolescent mothers and mothers that present with chronic disease or use alcohol among other drugs.

In this context, the future will take into account the Declaration of Alma-Ata towards health promotion, preventing the problem of children who are born prematurely or low birth weight.

Given the finding that dental decay is more prevalent in children with enamel defects, clean water and sanitation have proven to decrease this condition, this strengthens the need for healthcare focus in primary health care and common risk factors to health promotion.

Thus, the future will be much simpler than the past.

This prediction will change caries distribution in economically developed nations

Currently, clinical trials and systematic reviews have not been able to prove the effectiveness of Fluoride Varnish on arresting caries, even taking into account that the concentration of fluoride in these products is high, 22,600 ppm (*Santos Junior et al., 2012*). Nevertheless, the use of fluoride will continue into the future. However, there will be controversies and paradigm shifts.

The example of Dr. Michael Buonocore, which changed dentistry from `Drills, Fills and Bills' will drive the dental profession into new roles and strategies with treating caries.

Furthermore, "Howe's solution," Silver Nitrate, applied to arrest tooth decay for over 100 years, is a method of sterilizing and at the same time impregnating the tooth with a metal affected dentinal tissue (*Targino et al., 2010*).

Nonetheless, as the future will be more straightforward than the past, the use of Silver Nitrate will be of benefit as a caries halting treatment to provide access to health care of children, in poor communities. It may be more accessible than SDF, the same formulation with the addition of 44-ppm of fluoride to the solution (*dos Santos et al., 2014*).

Currently, there is no evidence of the difference in effectiveness of the treatment with Howe´s Solution, compared to silver diamine fluoride.

The challenge of this new century is mainly to arrest decay in open cavities of children that still lack access to regular dental check-ups and those who need treatment in an operating room.

Restorative dentistry for deciduous teeth requires more than plastic restorations and evolve in the best practice, the use of pre-formed stainless-steel crowns, by minimally invasive technique, which is unavailable for children in poor countries.

Thus, it merits consideration that Nano Silver Fluoride colloids may aggregate much higher concentration of Silver, because of the size of the Nano silver particles.

Since the use of fluoride marked the 20th Century, what will be the innovation in the future?

In the future, Nano silver compounds with a high concentration of Nano-Silver particles, with and without fluoride, may be widely used, as in the last Century. Howe´s solution and silver diamine fluoride.

It is naïve to think that the approach for health promotion, which worked for the XX Century, will efficiently work for the future, in an environment ruled by a new global economy focus on justice.

References

American Dental Association (2018). Evidence-Based Clinical Practice Guideline on Nonrestorative Treatments for Caries Lesions. www.ada.org/en/science-research/science-in-the-news/silver-diamine-fluoride-in-caries-management.

Andrade, K. C. G. E., Maciel, S. M., Guedes Pinto, A. C., Jaeger, R. G. (1992) Reações da dentina cariada após aplicação do Diamino fluoreto de prata a 10%: estudo através de microscópio eletrônico de varredura. RBO, 49, 6, 31-36.

Badu, N. V., & Joseph, R. (2005). Dr. Michael Buonocore - "Adhesive Dentistry - 1955." Journal of Conservative Dentistry, 8(3), 43–44.

Brazil Ministry of Health (2012). National Research on Oral Health: Main Results. Ministry of Health, Secretariat of Health Care, Secretariat of Health Surveillance, Publisher MS – OS 2012/0335.

Buonocore, M. G. (1961). Dissolution Rates of Enamel and Dentin in Acid Buffers. Journal of Dental Research, 40(3), 561–570. https://doi.org/10.1177/00220345610400032501

Centers for Disease Control and Prevention. (n.d.). 2012 Water Fluoridation Statistics. Retrieved from cdc.gov website: https://www.cdc.gov/fluoridation/statistics/2012stats.htm

Collina, Elisângela da; Moreira, Márcia; Barbosa, Antônio Desidério (2000). Comparação da ação do verniz fluoretado Duraphat e do cariostático Bioride (Diamino Fluoreto de Prata 12 por cento), sobre a contagem de streptococcus do grupo mutans, em crianças com dentição decídua. Rev. ABO nac, 8, 1, 14-20.

Coutinho, T. C. L. (2002). In vitro study of cariostatic potential of resin sealants, glass ionomer cements, diamine varnish applied on occlusal surface of human permanent molars. Doctoral Dissertation. Universidade de Sao Paulo, Faculdade de Odontologia de Bauru.

Crystal, Yasmi O., et al. "Parental Perceptions and Acceptance of Silver Diamine Fluoride Staining." The Journal of the American Dental Association, vol. 148, no. 7, July 2017, pp. 510-518.e4, 10.1016/j.adaj.2017.03.013.

Cury, J. A., de Oliveira, B. H., dos Santos, A. P. P., & Tenuta, L. M. A. (2016). Are fluoride releasing dental materials clinically effective on caries control? Dental Materials, 32(3), 323–333. https://doi.org/10.1016/j.dental.2015.12.002

De Menezes Oliveira, M. A. H., Torres, C. P., Gomes-Silva, J. M., Chinelatti, M. A., De Menezes, F. C. H., Palma-Dibb, R. G., & Borsatto, M. C. (2009). Microstructure and mineral composition of dental enamel of permanent and deciduous teeth. Microscopy Research and Technique, 73, 572–577. https://doi.org/10.1002/jemt.20796

dos Santos Junior, V. E., de Sousa, R. M. B., Oliveira, M. C., de Caldas Junior, A. F., & Rosenblatt, A. (2014). Early childhood caries and its relationship with perinatal, socioeconomic and nutritional risks: a cross-sectional study. BMC Oral Health, 14(1). https://doi.org/10.1186/1472-6831-14-47 *dos Santos, V. E., Filho, A. V., Ribeiro Targino, A. G., Pelagio Flores, M. A., Galembeck, A., Caldas, A. F., & Rosenblatt, A. (2014). A New "Silver-Bullet" to treat caries in children – Nano Silver Fluoride: A randomized clinical trial. Journal of Dentistry, 42(8), 945–951. https://doi.org/10.1016/j.jdent.2014.05.017*

Dye, B., Xianfen, M., & Thornton-Evans, G. (2012). Oral Health Disparities as Determined by Selected Healthy People 2020 Oral Health Objectives for the United States. NCHS Data Brief, (104), 1–8. Retrieved from https://www.cdc.gov/nchs/data/databriefs/db104.pdf

Fava, M., Watanabe, I.S., Fava-de-Moraes, F., & Costa, L. R. de R. S. da. (1997). Prismless enamel in human non-erupted deciduous molar teeth: a scanning electron microscopic study. Revista de Odontologia Da Universidade de São Paulo, 11(4), 239–243. https://doi.org/10.1590/s0103-06631997000400003

Food and Drug Administration (2014). 510(k) Premarket Notification - 38% Silver Diamine Fluoride. Fda.Gov. www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpmn/pmn.cfm?ID=K102973.

Freire, P. L. L., Albuquerque, A. J. R., Farias, I. A. P., da Silva, T. G., Aguiar, J. S., Galembeck, A., … Rosenblatt, A. (2016). Antimicrobial and cytotoxicity evaluation of colloidal chitosan – silver nanoparticles – fluoride nanocomposites. International Journal of Biological Macromolecules, 93(Pt A), 896–903. https://doi.org/10.1016/j.ijbiomac.2016.09.052

Freire, P. L. L., Stamford, T. C. M., Albuquerque, A. J. R., Sampaio, F. C., Cavalcante, H. M. M., Macedo, R. O., … Rosenblatt, A. (2015). Action of silver nanoparticles towards biological systems: cytotoxicity evaluation using hen's egg test and inhibition of Streptococcus mutans biofilm formation. International Journal of Antimicrobial Agents, 45(2), 183–187. https://doi.org/10.1016/j.ijantimicag.2014.09.007

Gao, S.S., et al. "Clinical Trials of Silver Diamine Fluoride in Arresting Caries among Children." JDR Clinical & Translational Research, vol. 1, no. 3, 20 Aug. 2016, pp. 201–210, 10.1177/2380084416661474. Accessed 5 Aug. 2019.

Horst, Jeremy A, et al. "UCSF Protocol for Caries Arrest Using Silver Diamine Fluoride: Rationale, Indications and Consent." Journal of the California Dental Association, vol. 44, no. 1, 2016, pp. 16–28, www.ncbi.nlm.nih.gov/pmc/articles/PMC4778976/.

Howe, P. R., & Howe, P. R. (1917). A method of sterilizing and at the same time impregnating with a metal, affected dentinal tissue (Vol. 59, pp. 891–904). Philadelphia: S S White Dental Manufacturing Company.

Innes, N. P. T., & Evans, D. J. P. (2013). Modern approaches to caries management of the primary dentition. British Dental Journal, 214(11), 559–566. https://doi.org/10.1038/sj.bdj.2013.529

International Conference on Primary Health Care. (1978). Declaration of Alma-Ata International Conference on Primary Health Care, Alma-Ata, USSR, 6-12. Retrieved from http://www.who.int/publications/almaata_declaration_en.pdf

Kaste, L. M., Selwitz, R. H., Oldakowski, R. J., Brunelle, J. A., Winn, D. M., & Brown, L. J. (1996). Coronal Caries in the Primary and Permanent Dentition of Children and Adolescents 1–17 Years of Age: United States, 1988–1991. Journal of Dental Research, 75(2_suppl), 631–641. https://doi.org/10.1177/002203459607502s03

Low, I. M., Duraman, N., & Mahmood, U. (2008). Mapping the structure, composition and mechanical properties of human teeth. Materials Science and Engineering: C, 28(2), 243–247. https://doi.org/10.1016/j.msec.2006.12.013

Marinho, V. C., Higgins, J. P., Logan, S., & Sheiham, A. (2003). Topical fluoride (toothpastes, mouthrinses, gels or varnishes) for preventing dental caries in children and adolescents. Cochrane Database of Systematic Reviews, (4). https://doi.org/10.1002/14651858.cd002782

Medeiros, U. V., Miasato, J. M., Monte, A. L. A., Ramos, M. E., & Soviero, V. M. (January 01, 1998). Efeito cariostatico e preventivo do diamino fluoreto de prata a 30 por cento em pacientes bebes. Revista Brasileira De Odontologia, 55, 6, 340-4.

Narvai, P. C. (2000). Cárie dentária e flúor: uma relação do século XX. Ciência & Saúde Coletiva, 5(2), 381–392. https://doi.org/10.1590/s1413-81232000000200011

National Institute of Dental and Craniofacial Research. (n.d.). Dental Caries (Tooth Decay) in Children Age 2 to 11. From Nih.gov website: https://www.nidcr.nih.gov/DataStatistics/FindDataByTopic/DentalCaries/DentalCariesChildren2to11.htm

Nishino, M., Yoshida, S., Sobue, S., Kato, J., & Nishida, M. (1969). Effect of topically applied ammoniacal silver fluoride on dental caries in children. The Journal of Osaka University Dental School, 9, 149–155.

Oliveira, A. F. B., Chaves, A. M. B., & Rosenblatt, A. (2006). The Influence of Enamel Defects on the Development of Early Childhood Caries in a Population with Low Socioeconomic Status: A Longitudinal Study. Caries Research, 40(4), 296–302. https://doi.org/10.1159/000093188

Pesquisa do IBGE indica que mortalidade infantil permanece em queda. (2016, November 24). Retrieved from Agência Brasil website: http://agenciabrasil.ebc.com.br/direitos-humanos/noticia/2016-11/pesquisa-do-ibge-indica-que-mortalidade-infantil-permanece-em-queda

Petersen, P. E., & Ogawa, H. (2016). Prevention of dental caries through the use of fluoride--the WHO approach. Community Dental Health, 33(2), 66–68.

Pinto, L.P., Souza, L.B., Lisboa, J.F., Nesi, M.A., Almeida, D., Oliveira, O.X., & Oliveira, A.X. (1987). Prevenção de cáries de radiação pelo diamino fluoreto de prata a 10 por cento em pacientes submetidos a radioterapia em regiões de cabeça e pescoço (Nota prévia). University of Sao Paulo. Rev. Odontol, 1, 1, 61.

Prado, C. (2017). Delírios Utópicos de Claudio Prado - Ministério da Felicidade, Drone e a porraloquice do século 21 [YouTube Video]. Retrieved from https://www.youtube.com/watch?v=FoeTp1YaW4I

Promoting the oral health of children : Theory and practice. (2nd ed., p. Chapter 3). (2014). Quintessence Publishing.

Wambier, D. S., Bosco, V. L. (1995). Rev Odontopediatr, 4, 35-41

Ribeiro, A. G., Oliveira, A. F. de, & Rosenblatt, A. (2005). Cárie precoce na infância: prevalência e fatores de risco em pré-escolares, aos 48 meses, na cidade de João Pessoa, Paraíba, Brasil. Cadernos de Saúde Pública, 21(6), 1695–1700. https://doi.org/10.1590/s0102-311x2005000600016

Rosenblatt, A., et al. "Silver Diamine Fluoride: A Caries 'Silver-Fluoride Bullet.'" Journal of Dental Research, vol. 88, no. 2, Feb. 2009, pp. 116–125, 10.1177/0022034508329406.

Santos Junior, V. E. dos, Vasconcelos, F. M. N. de, Souza, P. R. de, Ribeiro, A. G., & Rosenblatt, A. (2012). Adverse events on the use of interim therapeutic in schoolchildren: silver diamine fluoride × interim therapeutic restorative - a pilot study. Revista Odonto Ciência, 27(1), 26–30. https://doi.org/10.1590/s1980-65232012000100005

Sheiham, A., & Watt, R. G. (2000). The Common Risk Factor Approach: a rational basis for promoting oral health. Community Dentistry and Oral Epidemiology, 28(6), 399–406. https://doi.org/10.1034/j.1600-0528.2000.028006399.x

Silverstone, L. M. (1970). The histopathology of early approximal caries in enamel of primary teeth. ASDC Journal of Dentistry for Children, 37(3), 201–210.

Sperber, G. H., & Buonocore, M. G. (1963). Enamel Surface in "White-Spot" Formation. Journal of Dental Research, 42(2), 724–731. https://doi.org/10.1177/00220345630420022101

Targino, A. G. R., Flores, M. A. P., dos Santos Junior, V. E., de Godoy Bené Bezerra, F., de Luna Freire, H., Galembeck, A., & Rosenblatt, A. (2014). An innovative approach to treating dental decay in children. A new anti-caries agent. Journal of Materials Science: Materials in Medicine, 25(8), 2041–2047. https://doi.org/10.1007/s10856-014-5221-5

Targino, A., Rosenblatt, A., Oliveira, A., Chaves, A., & Santos, V. (2010). The relationship of enamel defects and caries: a cohort study. Oral Diseases, 17(4), 420–426. https://doi.org/10.1111/j.1601-0825.2010.01770.x

The New York Times (2016). A Cavity-Fighting Liquid Lets Kids Avoid Dentists' Drills. www.nytimes.com/2016/07/12/health/silver-diamine-fluoride-dentist-cavities.html.

Wambier, D. S., Bosco, V. L. (1995). Use of cariostatic in pediatric dentistry: silver diamine fluoride.

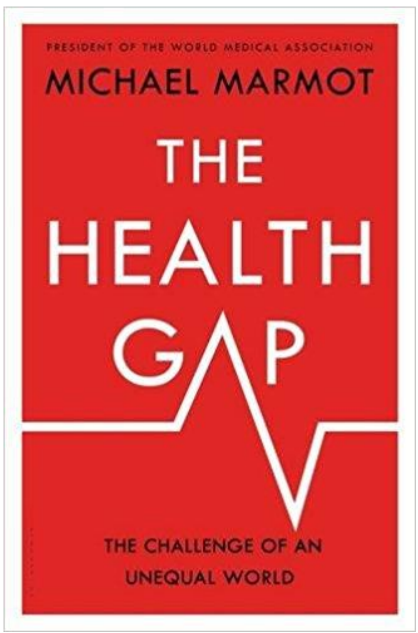
Wambier, D.S., Simionato, M.R., Bandeira, L.R., & Adimari, L.A. (2002). Avaliação de três materiais utilizados na fase preparatória do meio bucal. JBP, j. Bras. Odontopediatr. Odontol, 5, 25, 230-234.

Watt, R. G., & Sheiham, A. (2012). Integrating the common risk factor approach into a social determinant's framework. Community Dentistry and Oral Epidemiology, 40(4), 289–296. https://doi.org/10.1111/j.1600-0528.2012.00680.x

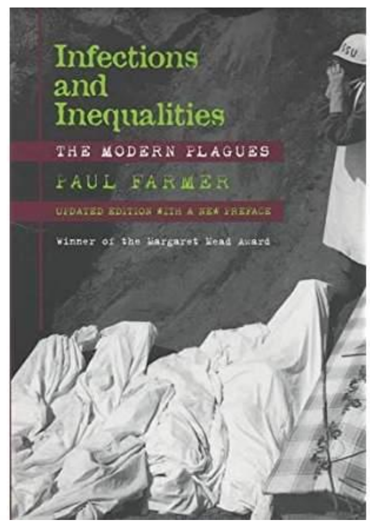
Yamaga, R., Nishino, M., Yoshida, S., & Yokomizo, I. (1972). Diammine silver fluoride and its clinical application. Journal of Osaka University Dental School, 12, 1–20.

Recommended Readings

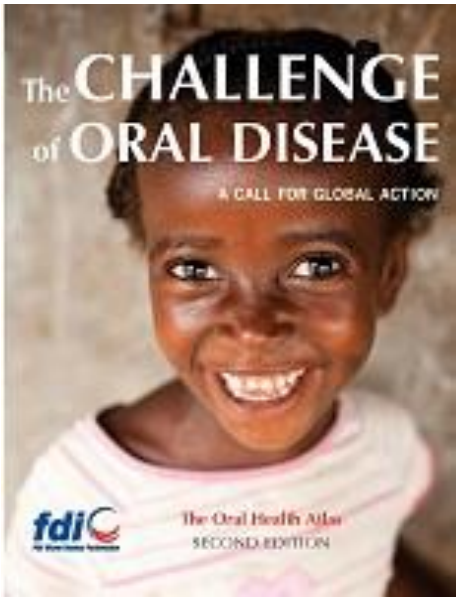
The following books are recommended as seminal and invaluable contributions to the development of Medical Management of Caries.
S. Duffin



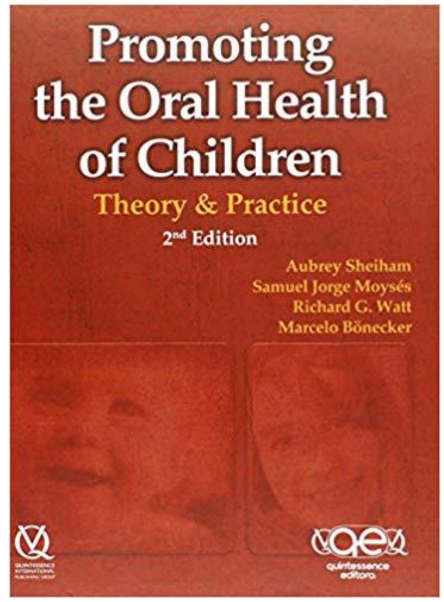
The Health Gap by Michael Marmot defines the challenges in public health practice. I highly recommend placing this book very high on ones reading list.



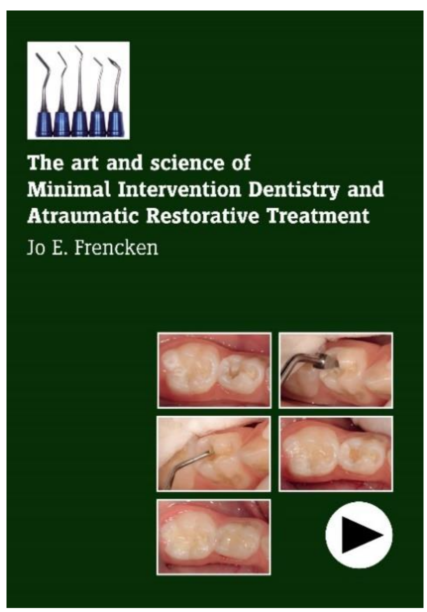
Paul Farmer is the embodiment of a modern-day Albert Schweitzer. His book Infections and Inequalities is a masterpiece. No individual engaged in public health practice should be absent of this important material.



This important survey of oral disease on a global scale is produced by the FDI, World Dental Federation and is a must read for anyone interested in the subject of oral health.



Recently I had the privilege to read Promoting the Oral Health of Children by Aubrey Sheiham. I strongly encourage every professional that is interested in children's oral health to read this book, then re-read it, then give it away to an interested colleague.



As we were coming to completion of this manuscript, I (SD) had the opportunity to meet with Dr. Jo Frencken at the IADR 2018 meeting in London and to receive his latest book above. This book is a wonderful description of the evolution of the atraumatic

Index