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CARIES

MOVING
FROM
RESTORATION
TOWARD
PREVENTION
PART 1

John D.B. Featherstone, MSc, PhD
Jon R. Roth, CAE





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Side by Side

STEVEN A. GOLD, DDS

February is widely known throughout the dental profession as National Children's Dental Health Month. This year, professional and public awareness of this designation is even higher thanks to the ADA-driven Give Kids a Smile program. This campaign will no doubt receive an ample amount of well-deserved coverage in both dental and nondental publications. Therefore, I would like to acknowledge the other designation given to the month of February, Black History Month.

When I was a second-year dental student, I had the privilege of attending the ADA Annual Session for the first time. I remember walking through the maze of exhibitors and seeing a booth for the National Dental Association. I surmised that this was an association of African American dentists. I wondered to myself why black dentists had an organization of their own and what the relationship of this organization is to the ADA. It took nearly 10 years, but I was finally enlightened to the answers. Black dentists formed their own professional organization because, at one time, they were denied membership in the ADA and its component societies. And as for the relationship of the NDA to the ADA, it is ever evolving and steeped in a rich history.

The history of African American dentistry and the National Dental Association has been forged by the efforts of many individuals spanning more than 150 years to the present day. Space will not allow mentioning all of these men and women here. For a most detailed and eruditely written chronicle of the entire NDA story, I recommend the book NDA

II, *The Story of America's Second National Dental Association* by Dr. Clifton O. Dummett and Lois Doyle Dummett (reviewed in the March 2001 CDA Journal, Vol. 29, Page 3). I have relied shamelessly on it for the following accounts.

Consider the courage and perseverance of Dr. Robert Tanner Freeman. After being denied admission to several dental schools on account of his race, he was accepted at Harvard University's School of Dental Medicine, and in 1869 became the first African American to receive a dental doctorate degree from a U.S. university. Then there was the vision and leadership of Dr. Robert Fulton Boyd, who in 1895 became the first president of the National Medical Association, at that time encompassing the professions of medicine, dentistry, and pharmacy. Boyd was well-prepared for this role, having received both an MD degree and a DDS degree; and he admirably served his profession and community in many capacities during his career.

At the onset of the turbulent 1960s, the daring and uncompromising actions of Drs. Roy C. Bell and Eugene T. Reed, both staunch civil rights advocates, underscored the fact that progress toward racial equality is not always gained with patience, civility, and deliberate negotiation. In March of 1961, Bell, a Georgia dentist, led a contingent of eight black dentists in a picket line outside of the Thomas P. Hinman meeting in Atlanta. In spite of their prior peaceful and legitimate attempts at professional racial integration, the Hinman meeting remained closed to African American dentists. Meanwhile Reed, a New York dentist, was staging his own protest against overt

discrimination. After refusing to move from a “whites only” section of a diner, he was arrested and convicted of trespassing by an all-white jury. These two individuals displayed unwavering bravery in the face of potentially severe negative repercussions. Their actions drew attention that not only moved the National Dental Association forward, but also helped inch all African Americans one step closer to racial equality.

Throughout the early part of the 20th century, black dentists began slowly integrating into ADA constituent and component dental societies. Yet even as this was occurring in some areas of the country, in others, notably the Southeastern states, blacks were excluded from membership into the 1960s. Following enactment of civil rights laws, ADA finally passed a series of resolutions, in essence, banning all racially motivated membership restrictions amongst its components and constituents. This occurred at the ADA House of Delegates in 1965, more than 100 years after the signing of the Emancipation Proclamation and the official dissolution of the institution of slavery.

The arrival of the 21st century has seen a new chapter in ADA and NDA relations. The NDA has long had government relations and legislative advocacy activities that have paralleled those of the ADA and its constituent associations. Last year, the two organizations collaborated in an unprecedented way. When Rep. Diane Watson (D-Los Angeles), who is African American, sponsored federal legislation to ban the use of amalgam based largely on scientifically unsubstantiated claims, the ADA legislative team sprung into action. Meetings were quickly arranged with legislators and their staffs to provide factual information on amalgam, from its safety as a material to its public health benefits. One person the ADA could not secure a

meeting with, however, was Rep. Watson herself. Leaders of the National Dental Association stepped up to the plate and did secure a meeting with her, dutifully representing all American dentists. While the outcome of this legislation is still unclear, what is clear is that there is a new solidarity between the ADA and NDA.

The inferno of racism in this country has been quelled yet still it smolders and occasionally flares up and engulfs our efforts at equality. To those stuck in the antiquated cycle of racial division, we hope that the dental profession may set an example of how two organizations with radically different histories can come together and work toward a common goal. We hope that African American dentists may continue to cherish and celebrate their proud history through membership in the National Dental Association. Yet we also hope they realize that they are not only welcome, but also sorely needed as part of ADA, CDA, and the local component societies. If the future of dentistry is to be as bright as its past, dentists of every color and background must stand side by side to vigilantly guard the profession we all belong to.

Study Supports Removal of Third Molars

The next time you see a patient who is experiencing no problems with his or her third molars, what should you do?

A recent study sponsored by the American Association of Oral and Maxillofacial Surgeons and the Oral and Maxillofacial Surgery Foundation and published in the November 2002 *Journal of Oral and Maxillofacial Surgery* strongly suggests the removal of third-year molars before age 25. The results of the study are challenging two long-held beliefs: that third molars that have broken through the tissue and erupted into the mouth in a normal, upright position have minimal problems, and that the absence of symptoms from retained third molars indicates that the teeth are free from problems.

Investigators led by Raymond P. White, Jr., DDS, PhD, and Richard H. Haug, DDS, conducted the 30-month institutional review board-approved longitudinal clinical trial. They examined the health of the tissues supporting teeth throughout the mouth, including the third molars of more than 300 healthy patients between the ages of 14 and 45, who had four symptom-free third molars with adjacent second molars. They used standard methods of evaluating the tissues that surround and support the teeth, including probing depth analysis, calculation of a gingival index, and X-ray examination. They also took dental plaque samples and determined the presence and levels of bacteria in these samples. If the probing depth analysis measured a depth of 5 mm or greater, which is an accepted determining sign of periodontitis, they observed that:

- 25 percent of all study-enrolled patients, and 34 percent of African American patients, had at least one probing depth equal to or greater than 5 mm behind a second molar and around a third molar.
- A higher proportion of patients 25 years old or older (33 percent) had a probing depth equal to or greater than 5 mm

behind a second molar and around a third molar compared with patients younger than 25 (17 percent).

- Complexes of bacteria previously shown in scientifically designed clinical studies to be associated with periodontitis, were detected at higher levels in plaque samples of patients who had at least one probing depth equal to or greater than 5 mm behind a second molar and around a third molar.

“The results of this large, ongoing study only serve to reinforce what many of us have suspected and seen over the years,” said John S. Bond, DMD, president of the California Association of Oral and Maxillofacial Surgeons. “Frequently, even when third molar teeth are erupted in the mouth, they often result in problems with the adjacent second molar teeth over the years.”

The results of these investigations further indicate that patients who do not have their third molars removed prior to age 25 may be at greater risk for the development of disease affecting the tissues surrounding the second and third molars and that early stages of periodontitis may present first in the third molar regions in young adults.

The investigators note that disease behind second molars or around third molars may be attributable in part to the patient’s inability to keep the area clean. This would, in turn, allow infectious bacteria to grow and begin the disease process, which could worsen over time. Additionally, third molars that have broken through the tissue and erupted into the mouth in a normal, upright position are as likely to exhibit disease as those third molars that remain impacted or buried.

“Having a patient’s third molars evaluated and removed by an oral and maxillofacial surgeon where indicated prior to the patient reaching the age of 25 results in a far easier postsurgical course for the patient,” Bond said. “Importantly, it also prevents or eliminates the problems that all too frequently arise as the patient ages if they are ignored or forgotten until pocketing or other disease processes present.”

For further information on the study, contact the American Association of Oral and Maxillofacial Surgeons at (847) 678-6200 or visit their Web site at www.aaoms.org.

Use of Nitrous Oxide Can Affect Vision of Some Eye Surgery Patients

Patients may lose their sight if they receive nitrous oxide anesthesia within one month after having retinal surgery, a new study reported by Reuters suggests.

Researchers from New Zealand described the cases of three patients who received intraocular gas, which is used to hold the retina in place during surgery to repair retinal detachment.

Within one month, the patients had other types of surgery unrelated to their eye operation. All three patients, who received nitrous oxide gas as anesthesia for their second surgery, suffered severe vision loss immediately after they received the anesthetic. Vision loss was permanent in two of the patients.

Dr. David R. Worsley, the study’s lead author, explained that nitrous oxide can cause an intraocular gas bubble to expand, increasing the pressure within the eye and inhibiting circulation to the optic nerve and retina.

“Without a blood supply, these tissues are soon irretrievably damaged, resulting in vision loss that is frequently severe,” Worsley said.

FDA Releases Final Rule on Classification of Sleep Apnea Devices

The Food and Drug Administration has announced its final rule that changes the classification of intraoral devices for the treatment of snoring and obstructive sleep apnea to Class II (special controls). This rule became effective Dec. 12, 2002.

Formerly, these appliances remained unclassified as medical devices by the FDA. According to Dr. Susan Runner of the Center for Devices and Radiological Health, the regulation will help increase the legitimacy of oral appliance therapy for the treatment of sleep-disordered breathing. This may also add to the recognition of oral appliances by insurance providers, thus increasing the possibility for reimbursement to practitioners performing these procedures.

Class II refers to medical devices requiring special controls to ensure public health and safety, such as intraoral soreness, TMD, obstruction of oral breathing, loosening or flaring of lower teeth, general tooth movement, and others defined by an FDA guidance document. Mandating these considerations will add medical validity to the use of these appliances.

Dr. Harold A. Smith, president of the Academy of Dental Sleep Medicine, said, "The FDA classification of oral devices is a forward step in the future of oral appliance therapy, but more importantly, will ensure the effective treatment and overall health of patients."

For more information regarding the FDA regulation on medical devices, a copy of the FDA guidance document, or a list of devices currently cleared by the FDA, please visit the Academy of Dental Sleep Medicine's Web site at www.dentalsleepmed.org.

UCSF Receives \$1.2 Million Grant to Prevent Oral Cancer

In a nationwide project to fight oral cancer through prevention and early detection, the National Cancer Institute has awarded \$1.2 million to researchers at the University of California at San Francisco School of Dentistry to create a program of oral cancer prevention in collaboration with the American Dental Association.

Oral cancer strikes more than 30,000 Americans and accounts for more than 9,000 deaths each year in the United States. Despite advances in oral cancer treatment, only about one-half of all people diagnosed with the disease survive more than five years.

"Early detection is the most important approach in decreasing the morbidity and mortality of oral cancer," said Sol Silverman, Jr., DDS, UCSF professor of oral medicine and principal investigator of the five-year project. Silverman is a consultant to the ADA Council on Access, Prevention, and Interprofessional Relations and a pioneer and expert in oral cancer education, patient care, and research.

The UCSF researchers will develop and implement a continuing education program focusing on oral cancer prevention education for practicing dentists in the United States. Key components will include risk assessment and risk reduction for tobacco and alcohol use, chemoprevention, early detection, and diagnosis.

Data indicate that the majority of at-risk Americans do not benefit from oral cancer screening from their primary care professionals, and survival rates have not significantly changed in the past 20 years, according to Silverman. The plan is to increase dentists' skills in early detection of oral cancer because, thus far, this is the most important approach in decreasing morbidity and mortality of oral cancer.

Enzyme Key to Dental Enamel Formation

A team of scientists from the Forsyth Institute and the National Institute of Dental and Craniofacial Research have discovered that an enzyme known as matrix metalloproteinase-20 is essential for proper formation and development of dental enamel in mice.

Since the enzyme is expressed in human teeth, the finding, in studies of mice, may be relevant to science's understanding of a human disease known as amelogenesis imperfecta, which causes one in approximately 7,000 children to be born with defective dental enamel, according to John Bartlett, PhD, associate member of the staff at the Forsyth Institute, and the principal investigator.

In the United States, the teeth of such children are ordinarily capped. Left untreated, the disease results in pain and even-

tual loss of teeth. Because of similarities between the mouse and human genomes, "it is possible that loss of this enzyme in humans would cause this disease," Bartlett said.

The article, "Enamelysin (MMP-20) deficient mice display an amelogenesis imperfecta phenotype" was published in the Dec. 20, 2002, issue of the *Journal of Biological Chemistry*. It is available at www.jbc.org.

Honors

John C. Greene, DMD, MPH, has been honored with the 2002 Tuttle Award, given annually by the National Spit Tobacco Education Program for national leadership in spit tobacco education and prevention. Dr. Greene is dean emeritus at the University of California at San Francisco School of Dentistry.

Mussels and Barnacles May Some Day Yield New Dental Adhesives

The greatest expansion in adhesive dentistry probably will be at the molecular level and secretions from mussels and barnacles may play a role, wrote Drs. Franklin R. Tay and David H. Pashley in the *Journal of Adhesive Dentistry*, Vol. 4, No. 2, 2002.

They said that this expansion will require far more collaboration between molecular biologists and polymer chemists than has previously occurred.

Adhesive dentistry has progressed at a rapid rate during the past decade, according to the authors. A large part of this success is attributed to the significant advances in dentin bonding technology.

From the early generation systems in the 1970s that yielded weak and unpredictable bonds, to contemporary hydrophilic systems that produce significant improvement in the strength of bonding to normal dentin, the progress in the development of dentin adhesives has been nothing short of phenomenal, wrote Tay and Pashley.

The current trend in the development of dentin adhesives, they said, is to simplify bonding steps and make them more user-friendly. However, they noted, optimizing speed and efficiency should be accomplished without major tradeoffs in the quality or durability of resin bonds.

With the advances in biomimetics, future dentin adhesive monomers may contain domains derived from protein-based, underwater bioadhesives secreted by aquatic animals such as mussels and barnacles, making them less dependent on the surface energy of the bonding substrates as well as less susceptible to hydrolytic degradation.

Using the concept of controlled release, future adhesives may contain fluorescent biosensors that can detect pH changes around leaking restorations. The authors said these adhesives may even have the capacity to heal autonomously, in response to microcracks formed by functional stresses within the adhesive joint. The ability to self-diagnose and self-repair will increase the life expectancy of adhesive restorations.

According to the authors, future dentin adhesives may also assume a more instrumental role in therapeutics apart from caries prevention. These features may include the controlled release of noncollagenous proteins to promote remineralization of collagen matrices and growth factors to induce controlled formation of reparative dentin.

Cariology in the New World Order: Moving From Restoration Toward Prevention

JOHN D.B. FEATHERSTONE, MSc, PhD, AND JON R. ROTH, CAE

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Since the early 1960s, when the health care model began emphasizing prevention, the dental profession has struggled with the balance between expending resources on preventive health measures and on surgical treatment for oral diseases.

We are all familiar with the success of water fluoridation in reducing the prevalence of dental caries in the 1960s and 1970s. The introduction of fluoride dentifrice and other fluoride products led to another major reduction in dental caries in the late 1970s and 1980s. The “gold standard” for prevention became dentists convincing their patients to engage in a routine regimen of brushing with a fluoride dentifrice and engaging in regular flossing. Still today, dentists and their staff spend countless hours educating patients on the importance of this daily exercise; and yet, dental caries continues to be a major problem in children and adults.

This preventive model, as well as a focus on community water fluoridation nationwide, reduced the prevalence of dental caries in the United States. However, as the demography of California and the rest of the nation shifts at a rapid rate, we find ourselves in a contradictory circumstance with dental caries dramatically increasing in some segments of the population. Dental caries is now the single most common chronic disease in children. There are five times more children in the United States with untreated dental disease than with childhood

asthma, and the manifestation results in more than 50 million missed school hours every year.

With so much disease, it is easy to get caught up in an endless treatment cycle to “fix” the problem using traditional surgical restorative approaches. However, we need also to keep focused on the wonderful partial success of prevention that took us to new levels of health in the 1970s and '80s. Fluoride therapy has taken us to a point, but alone it is not enough; and we must continue exploring additional new procedures for reducing dental caries that will advance prevention to the next level. Dental caries is a bacterial infection that is transmissible. We have to deal with the bacteria as well as to enhance remineralization and repair of early lesions.

In this two-part series, we hope to provide an update not only on the biological research and background of cariology, but also on the application of innovative methods to manage dental caries based upon risk assessment, intervention, and prevention of this transmissible infection. This two-part series is the outgrowth of a conference hosted by the California Dental Association Foundation in April 2002, where experts came together to review and update the science and practice of caries prevention.

In Part I of this series, we asked some of the leading researchers in dental caries to help us set the stage with information on the biological mechanisms of caries, the current problems, especially in California, and to begin to suggest

ways to deal with the situation in the home, in dental practices, and in community settings. Their work will share revealing information regarding the scope of dental caries as a health concern as well as the clinical identification and transmission of dental caries.

- n James C. Crall, DDS, ScD, shares his expertise in the prevalence of caries. His paper will serve as a baseline for understanding the magnitude of the problem of dental caries, particularly among California's children.
- n John D.B. Featherstone, MSc, PhD, will illustrate the "caries balance" as the basis for understanding and dealing with caries. The article will present a brief overview of the dental caries process -- in particular, the management of dental caries -- with the role of early detection methods in the clinical management of caries.
- n Robert J. Berkowitz, DDS, will continue the epidemiological discussion with a paper on dental caries as an infectious and transmissible disease. His review will illustrate new findings demonstrating that predate infants acquire mutans streptococci from their caregivers and that horizontal as well as vertical transmission occurs.
- n Pamela K. DenBesten, DDS, MS, shares information pertaining to the etiology and manifestations of early childhood caries, a major issue in California.
- n Steven M. Adair, DDS, MS, will illustrate how advanced specialty education programs in pediatric dentistry are often overwhelmed with patients who need restorative and surgical care, often on an emergency basis. His paper contains several recommendations for strengthening the training of pediatric dental

residents in caries risk assessment and prevention, including the suggestion that pediatric dental training programs become "dental homes" for their patients.

- n Paul Glassman, DDS, MA, MBA, will share his extensive experience in providing services to people with special needs. He reviews strategies for overcoming informational, physical, and behavioral barriers to oral health care for people with special needs and presents a summary of the results of a conference, held early in 2002, on "Practical Preventive Protocols for Prevention of Dental Disease in People with Special Needs in Community Settings."

Next month, we will share hands-on clinical applications, based on these and additional reviews, as new interventions to advance caries prevention. We will also provide a risk assessment form for you to use in your practice that incorporates this research and represents the consensus of those at the April 2002 conference in Sacramento. Ultimately, we hope to provide you with tools to elevate the preventive gold standard in your own practice.

Also included in this issue is a free DVD, sponsored by the CDA Foundation, which provides you with six patient education videos (three English, three Spanish) using the concepts derived from the research presented in Part I and Part II of this series. We believe you will find this valuable educational series, titled "Easy Steps to Oral Health," an important communication linkage between the research discussed in these papers and your daily practice and interaction with patients.

California Children and Oral Health: Trends and Challenges

JAMES J. CRALL, DDS, ScD

ABSTRACT This paper highlights fundamental elements of the challenge of securing optimal oral health for California's children, now and in the future, and underscores the need for new strategies to reduce the risk of dental disease and expand access to effective services. Developing effective strategies to gain optimal oral health for California children, especially those that are most vulnerable to dental disease and its consequences, requires an appreciation of key dynamic factors that define this challenge and the degree to which these factors are modifiable in the near and long term. Particular attention is directed toward three principal elements: population demographics, levels of dental disease in California children, and factors affecting access to services for vulnerable groups of children. The concluding section addresses the need for strategic action.

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California is considered by many to be the nation's trendsetter in health consciousness and health promotion. But beneath this popular image of healthy Californians are troubling trends and reports about the oral health of substantial and growing numbers of California children and their inability to access basic services that can help promote, restore, and preserve their oral health. Marked increases in the number of children living in poverty in California, dental disease rates that far exceed national averages, and fewer than one in three Medicaid-eligible children having access to dental services paint a picture that

stands in sharp contrast to commonly held perceptions of health in this vast and diverse geosocial entity that is home to one in eight American children.¹⁻⁴

This paper highlights fundamental elements of the challenge of securing oral health for California's children, now and in the future, and underscores the need for new strategies to reduce the risk of dental disease and expand access to effective services. Developing effective strategies to gain optimal oral health for California children, especially those that are most vulnerable to dental disease and its consequences, requires an appreciation of key dynamic factors that define this challenge and the degree to which these

factors are modifiable in the near and long term. Particular attention is directed toward three principal elements: population demographics, levels of dental disease in California children, and factors affecting access to services for vulnerable groups of children. The concluding section addresses the need for strategic action.

Demographic Trends: A Major Underlying Force

- Increases in childhood poverty.
- Challenges of dealing with diverse cultures.
- The demographic profile of California's children has undergone dramatic changes during the past two decades. A recently released report by the National Center for Children in Poverty³ identified the following trends:
 - The number of low-income children in California has increased by almost 1.6 million since the early 1980s, from 2.77 million to 4.36 million. The number of California children in poverty has increased by 850,000, from 1.27 to 2.12 million.^a
 - One in six poor children in the United States currently lives in California compared to about one in 10 two decades ago.
 - California alone has accounted for all of the net national increase of 800,000 in the number of children in poverty since the late 1970s.
 - The child poverty rate in California increased from less than 20 percent during the period from 1979 to 1983 to 22 percent during the period from 1996 to 2000. During the same averaged time period, the national child poverty rate decreased from 19 percent to 18 percent.

The National Center for Children in Poverty report³ also points out that Hispanics have become a large and rapidly

growing majority of the poor children in California. Hispanic children now account for 61 percent of all poor children in California (up from 41 percent two decades ago), while the proportion of poor children who are white has decreased from 30 percent to 21 percent. The share of poor children who are African American has fallen from 16 percent to 7 percent.³ Thirty-four percent of California's Hispanic children live in poverty, a 14 percent increase from two decades ago. Poverty rates for African-American children declined from 32 to 24 percent during that same time frame, while the rate for white children remained nearly flat at about 11 percent. The poverty rate for Asian-American children was 19 percent during 1996-2000.^b

Immigration has had a major influence on the changing demographic profile of California's low-income families. The National Center for Children in Poverty report³ notes that some 46 percent of all children in California are immigrants, and nearly 60 percent of the poor children in California are immigrants. At 29 percent, the poverty rate for immigrant children is significantly higher than the 17 percent rate for nonimmigrant children. These children present a challenge not only from the standpoint of their sheer numbers, but also by virtue of diverse cultures and linguistics.

The National Center for Children in Poverty analyses of U.S. Census Bureau data also point out that California children are much more likely to live in working and two-parent families than they were two decades ago.³ More than two-thirds of poor children in California now live in families with at least one employed parent; and 48 percent of poor children in California are in two-parent families. Immigrants in poverty are more likely to be in working families than native-born

families in poverty.

Levels of Dental Disease: The Essence of the Problem

- Prevalence rates two times national averages.
- Even higher disease rates in rapidly emerging groups within the population.

Collecting state-level data on dental disease in children has not been a priority in California. In fact, a 1993-94 statewide oral health needs assessment of California children⁴ was reported to be the first such survey in California history, and it has not been repeated. Thus it represents the most recent comprehensive source of data for characterizing the dental status of California children.

Key findings from the 1993-94 California Oral Health Needs Assessment of Children⁴ include:

- More than 50 percent of all California school-age children were found to have untreated decayed teeth.
 - In 1993-94, the percentage of 6- to 8-year-old California children with untreated decay (55 percent) was more than twice the U.S. average for this age group in 1986-87. Comparisons with data from the Third National Health and Nutrition Examination Survey conducted from 1998 to 1994⁵ indicate that California children also were more than twice as likely to have untreated decay compared to national averages.
 - More than half (54 percent) of California 10th-graders were found to have untreated decayed teeth, and nearly 40 percent of 10th-graders in need of treatment had urgent dental care needs for extensive decay, pain, or infection.
 - Asian, black, and Latino children were found to have significantly higher rates of untreated decay compared

to their white counterparts. Disparities were particularly pronounced for young (preschool and elementary school) children regardless of race or ethnicity and for Hispanic adolescents.

- Nearly one-third of California preschoolers, 69 percent of California children in grades K-3, and 78 percent of California 10th-graders had experienced tooth decay.

The striking levels of untreated tooth decay in large proportions of California children -- more than 40 percent of nonwhite preschoolers, 40 percent to 68 percent of all elementary school children, and 38 percent to 75 percent of all high school-age youths -- highlight two distinct dimensions of the challenge of providing oral health for California children: (1) finding effective ways to extend known effective preventive interventions to all California children and (2) ensuring access to quality dental care for the millions of California children in need of treatment as well as preventive services.

Access to Effective Services: A Key Component of the Solution

- Trends in numbers of dental service providers.
- Extent of provider participation in public programs.
- Workforce distribution issues.
- Public sector infrastructure.

Space limitations do not allow for extensive discussion of the complex factors affecting access to services that could improve the oral health of California children or related trends. However, observations and trends regarding several key areas are highlighted below.

State dental workforce — According to data published by the Health Resources and Services Administration,⁶ California had the 10th-highest dentist-to-popu-

lation ratio of all 50 states in 1998, but ranked 26th in dental hygienist-to-population ratio and eight in dental assistant-to-population ratio. During the period from 1991 to 1998, California's dentist-to-population ratio declined by 8 percent. The number of dental hygiene graduates per 100,000 population declined by 4 percent from 1985-86 to 1995-96, while the number of dental assistant graduates per 100,000 population declined by 38 percent during that same period.

Dentist participation in Medicaid

— Data from the National Conference of State Legislatures⁷ indicate that 66 percent of practicing California dentists received at least one payment from Medicaid (Denti-Cal) in 2000 and that the percentage of dentists receiving at least one payment increased by 35 percent over the figure reported for 1998. The conference report also indicates that 29 percent of California dentists received payments of at least \$10,000 from Medicaid in 2000. In 1998, Medi-Cal payment rates varied from 17 percent to 68 percent of average regional dental fees, depending on procedure.⁸ Low fees are the main reason cited by dentists for not participating in the Medi-Cal program.⁹

Dental workforce distribution — In spite of relatively high dentist Medicaid participation rates in California, a recent report on the geographic distribution of California dentists¹⁰ found that:

- Of the 487 Medical Service Study Areas in California, 97 (20 percent) were at or below the federal Health Professional Shortage Area ratio of primary care dentists-to-population of 1:5000 in 1998;
- Sixty-six of the 97 shortage study areas (68 percent) were rural and contained 1.06 million people (3.1 percent of California's population), while 31 of the shortage study areas (32 percent) were

urban, containing 3.06 million people (8.9 percent of the state's population); and

- Of the 32 study areas that had no dentists, 31 were rural.
- Related data also indicate that of the 487 study areas in California, 108 had no active Medicaid dentists and that half of the study areas in California had less than one Medicaid dentist per 1,000 Medicaid beneficiaries.¹¹

Public sector infrastructure — Although the public oral health safety net infrastructure can include a broad array of entities and activities, attention is limited herein to care delivered in public community clinics. A recent report published by the University of California at San Francisco¹¹ noted that approximately 204 (30 percent) of the licensed community clinics in California offer some level of oral health care. Although the mission of most community health centers and other community clinics is to provide free or low-cost primary care to low-income and uninsured people, these centers generally face ongoing challenges of recruiting and retaining dental professionals and maintaining adequate financing. Without a mixture of federal, state, county, and private grants and reimbursement/payment, most clinics would not be sustainable.¹¹

Need for Strategic Planning and Action

Improving children's oral health and ultimately the oral health of the population requires attention to two broad strategies:

- Reducing the burden of oral diseases in the population through proven preventive measures and
- Providing disease management and treatment services to individuals who demonstrate clinical manifestations of oral diseases and their sequelae.

The factors underlying attainment of these goals are complex and require strategic planning and action that emphasize outreach, education, prevention, early intervention, access to quality care, and program evaluation and management based on sound data.^c

Considerable information and recommendations related to these issues have been compiled by various groups throughout California of late; however, absent a sustained, adequately supported, unified public-private effort and strong leadership, advances are unlikely. Additional papers in this issue and the next provide a foundation for developing new approaches for major oral health challenges facing California. Developing strategic initiatives and programs to effectively translate this information within the emerging contextual environment will be the key to future oral health in California.

Notes

- a. The National Center for Children in Poverty report defines a “low-income child or family” as living in a household with annual income less than 200 percent of the official poverty line (\$35,048 in 2000 for a family of four). In looking at the larger population of low-income families, it also includes demographic analyses of poor children and families using the poverty line (\$17,524 in 2000 for a family of four).
- b. The Census Bureau did not collect information to determine the child poverty rate among Asian-Americans during the 1979–1983 period.
- c. Additional background material on related oral health policy issues¹² and an example of using state-specific information to generate strategic planning and actions¹³ can be found at www.cthealth.org.

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The Caries Balance: Contributing Factors and Early Detection

JOHN D.B. FEATHERSTONE, MSc, PhD

ABSTRACT The aim of this article is to present a brief overview of the dental caries process, in particular, the management of dental caries and the role of early detection methods in the clinical management of caries.

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Dental caries is simply tooth decay. There is a small number of key contributing factors.¹ First, specific bacteria are involved that can metabolize fermentable carbohydrates and generate acids as waste products of their metabolism. The two principal groups of bacteria that have been implicated in dental caries are the mutans streptococci and the Lactobacilli species. The principal species in the mutans streptococci group are *S. mutans* and *S. sobrinus*. These bacteria are all called acidogenic because they produce acids from carbohydrates. When the acids are produced by the bacteria, they diffuse into the tooth enamel or dentin and dissolve or partially dissolve the mineral from crystals down inside the tooth. The tooth enamel and dentin are tissues made up of millions of tiny crystals. The mineral involved is

termed a carbonated hydroxyapatite.² This is a calcium phosphate with numerous impurity inclusions, the most important of which is the carbonate ion, which makes the mineral more acid-soluble than pure hydroxyapatite. If the dissolving of the mineral is not halted or reversed, the early subsurface lesion becomes a cavity. Last, dental caries is a transmissible bacterial infection.³⁻⁶

Dental caries occurs in deciduous teeth and permanent teeth, regardless of the age of the individual. Lesions vary from the very early lesion of enamel, which is manifested as a “white spot,” to frank open cavities. Early childhood caries is a similar process to later childhood and adult dental caries of enamel.⁷ Root caries is dental decay of the tooth root, which occurs in adults after the gingiva recede.⁸

What We Know About Caries

The process of dental caries is well-understood.¹ We know how demineralization (loss of mineral) and remineralization (regaining of mineral) occur, and we have a very good understanding of how fluoride works to inhibit or reverse dental caries. Much is known about the multiple roles of saliva and salivary components.⁹ We know that acidogenic bacteria (described above) cause demineralization and, therefore, caries. These bacteria are also termed cariogenic. The one major remaining area where much is still to be learned is in the complex microbiology that occurs in the dental plaque or so-called biofilm on the surface of the tooth. The role of fermentable carbohydrates in foods and beverages is well-understood; and it is known that sucrose, glucose, fructose, and cooked starch all contribute to the caries process.¹

Demineralization, i.e., loss of mineral from the tooth, is initiated by the cariogenic (acidogenic) bacteria that produce organic acids during their metabolism. These acids include lactic, acetic, propionic, and formic. All of these acids can readily diffuse into the tooth and dissolve the susceptible mineral. The dental mineral dissolves to produce calcium and phosphate into the aqueous solution between the crystals; and these ions diffuse out of the tooth leading to the formation of an initial carious lesion, which eventually can become a cavity if the process continues without reversal.¹⁰ The reversal of the process is remineralization (replacement of mineral), which occurs when the acid in the plaque is buffered by saliva allowing calcium and phosphate, primarily from the saliva, to flow back into the tooth and form new mineral on the partially dissolved subsurface crystal remnants.¹¹ The new “veneer” on the surface of the crystal is much more resistant to subsequent acid attack, especially if it is formed in the presence of sufficient fluoride.^{1,12}

Fluoride Mechanism of Action

It is now known that the primary mechanisms of action of fluoride are topical, i.e. they work by fluoride being available at

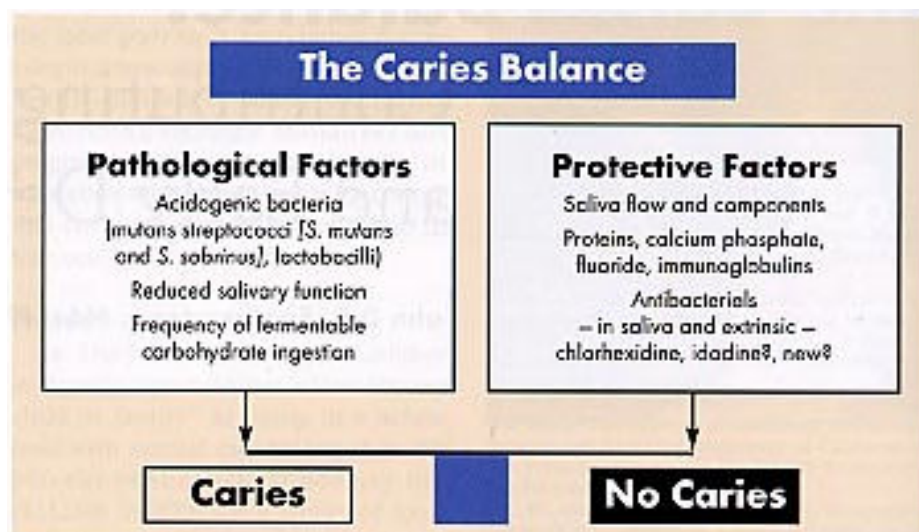


FIGURE 1. SCHEMATIC ILLUSTRATION OF THE “CARIES BALANCE.” ADAPTED FROM FEATHERSTONE.^{1,16}

the surface of the tooth. These aspects were thoroughly reviewed and agreement reached at an international consensus conference in 1989 and have been summarized extensively in other review papers.¹³⁻¹⁵ In summary:

- Fluoride inhibits demineralization;
- Fluoride enhances remineralization; and
- Fluoride can inhibit plaque bacteria.

The Caries Balance

Based upon the above summary of our in-depth knowledge of the caries process, it is very useful and constructive clinically to consider caries in its progression or reversal as an ongoing and often changing balance between pathological factors and protective factors.^{1,16} As illustrated in Figure 1, if the pathological factors outweigh the protective factors, then caries progresses. In the reverse situation, caries is arrested or even reversed. The pathological factors include the acidogenic bacteria, reduced salivary function, and the frequency of ingestion of fermentable carbohydrates. The protective factors include saliva and its numerous caries-protective components: the saliva flow; antibacterials, both intrinsic from saliva and extrinsic from other sources; and other factors that can enhance remineralization.

In most individuals, there are numerous acid challenges daily as fermentable carbohydrates are ingested and the struggle between the pathological factors and the protective factors takes place. First, as the acid is produced by the bacteria, mineral dissolves; and subsequently, as the saliva neutralizes the acid, mineral is replaced. Fluoride enhances this remineralization process when it comes from topical sources such as drinking water, food and beverages, toothpastes/dentifrices in general, mouth rinses, office-applied fluoride preparations, or from higher-concentration products including fluoride varnish (Figure 1). The next question that we must ask is if fluoride is so effective why do millions of people still require treatment annually in the United States for dental decay. Simply, if the bacterial challenge is too high, the beneficial effects of fluoride can be overcome by the acid attack. In the case of high-caries-risk individuals, although fluoride helps to reduce the amount and severity of the decay, it cannot overcome the high bacterial challenge. Figure 2 illustrates the mean decayed, missing, and filled surfaces in three national surveys in the United States. A dramatic reduction in decay levels was observed between 1970 and 1990. Prior to 1970, dramatic reductions in decay were also observed due to the fluoridation of

public water supplies. From 1970 onward, several factors were involved including the almost universal utilization of fluoride dentifrices.²⁰

Unfortunately, since 1990 there has been a plateau in the reduction of caries. This means that to further reduce the prevalence of dental caries and to address those who continue to have high levels of dental caries, we must use other measures. A recently published survey on the dental health of California's children from data that was accumulated in 1993 and 1994²¹ illustrated that:

- 27 percent of preschoolers have untreated decay;
- 53 percent of 6- through 8-year-olds have untreated tooth decay;
- 50 percent to 75 percent of minority high school students need dental care;
- California's children on average have twice the national average of untreated tooth decay.

In California, early childhood caries is a major issue.⁷ Essentially the process and etiology are the same as caries in older children and adults and involves the same bacteria. In the case of early childhood

caries, the decay is rampant and requires aggressive and multiple intervention strategies to control it.

Caries Is a Transmissible Bacterial Infection

It has been known for many years that caries is a bacterial infection.²² Studies during the past 25 years clearly indicate that the bacteria involved are transmissible, and the transmission, especially of *S. mutans*, is reviewed thoroughly by Berkowitz.⁴ In practical dentistry in the United States, we pay little attention to this basic fact about caries. We treat the manifestations of the disease rather than treating the disease itself. It is obvious that the next steps that must be taken to control, if not eradicate, dental caries must focus on the bacteria. One startling fact, which is not considered in practical dentistry, is that placing restorations to fill the cavities has no measurable effect on the cariogenic bacterial loading in the remainder of the mouth.²³ These earlier findings have been borne out by an ongoing study²⁴ in which a group of adult subjects with initial frank cavitation has been receiving conventional dental care according

to the current "standard of care." The levels of mutans streptococci and lactobacilli were measured at the beginning of the study and after restorations were completed, with the net result that mutans streptococci levels were not statistically significantly different after the completion of restorations unless antibacterial therapy by chlorhexidine was used. This means that for high-risk individuals with high levels of cariogenic bacteria, we must take steps to reduce the bacterial loading along with restorative work. There are several guiding principals that can be followed:

- Fluoride is effective only up to a point;
- A high bacterial challenge cannot be completely overcome by even high-concentration fluoride therapy;
- Placing restorations and conducting restorative work does not reduce the overall cariogenic bacterial loading in the mouth; and
- We need to break the chain of infection if caries is to be controlled in these individuals.

As described briefly above, caries involves multiple acidogenic species of bacteria, which means that a vaccine for one particular species will not necessarily have a beneficial effect on the overall caries status of the individual. We need to utilize antibacterial therapy to reduce the bacterial challenge and allow the protective factors in the above-described caries balance to take over. We need to find ways to break the chain of infection, for example, from mother to child. It is now well-established that mutans streptococci can be readily transferred from mother to child or caregiver to child or indeed from child to child or adult to adult.⁴ Antibacterial therapy with chlorhexidine is one immediate alternative, but this is effective for mutans streptococci and not for lactobacilli.²⁵ New antibacterial therapy is needed. As reviewed by Den Besten and Berkowitz, it is possible that iodine therapy may be more effective than chlorhexidine.⁷ Recent studies have shown that xylitol has properties that inhibit the establishment of cariogenic bacteria, and this appears to be an excellent method of breaking the chain of infection.²⁶

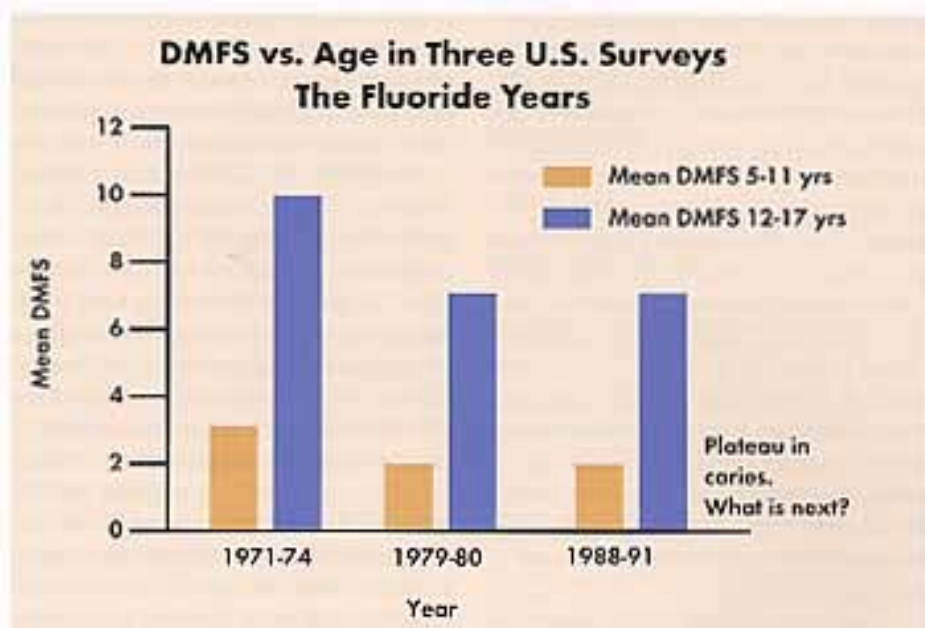


FIGURE 2. Mean decayed missing and filled surfaces (DMFS) in permanent teeth of U.S. children (age ranges as shown) in three national surveys.¹⁷⁻¹⁹

Conservative Caries Management

Conservative caries management has the idealized outcome that more tooth structure is preserved and fewer teeth become affected by dental decay. There are a few guiding principles:

- Detect caries lesions early enough (see below) so that the early, noncavitated lesion can be reversed or at least arrested from progressing by chemical means rather than by “restoration” (placing fillings);
- Assess the individual risk of caries progression (see below);
- Use fluoride to enhance remineralization and/or reduce the bacterial challenge by the use of antibacterial therapy;^{1,25,27-29} and
- Use minimally invasive restorative procedures to conserve tooth structure.^{28,30}
- The longevity of the tooth is much greater in the scenario of conservative caries management; many more teeth are preserved as caries free, and those that do require restorative work have much smaller restorations leading to much less fracture in the long term.

Early Caries Detection

Until recently, caries detection methods have been visual, tactile (with an explorer), and radiographic. Visual inspection can be quite effective when done by an experienced dentist, and new classifications are in use in Europe that could well be useful in the United States.³¹ However, this is obviously limited where the surface of the tooth is obscured and in occlusal surfaces, where “hidden lesions” may be missed. Radiographs as done with “bitewings” have long been useful for detecting interproximal lesions. The current standard of care is that if an enamel lesion, as detected by the radiograph, is not past the dentino-enamel junction, then it can be arrested or reversed by remineralization, whereas an opacity into the dentin requires clinical physical intervention (drilling and filling). This method is quite reliable for these lesions. However occlusal surfaces are



FIGURE 3. THE LEFT PANEL SHOWS A CONVENTIONAL BITEWING RADIOGRAPH WITH AN INTERPROXIMAL LESION ON THE LEFT AND A SHADOW AT THE DEJ UNDER THE OCCLUSAL SURFACE (ARROWS). THE RIGHT PANEL SHOWS A HEMI-SECTION OF THE SAME TOOTH ILLUSTRATING THE HIDDEN LESION EXTENDING TO THE PULP UNDER THE OCCLUSAL SURFACE (COURTESY OF D.A.YOUNG).

very different. In this case, there is a large amount of surrounding sound enamel that absorbs the X-rays; and only an advanced lesion can be detected in this fashion with conventional bitewing radiographs. This is illustrated in Figure 3, where the lesion under the occlusal surface was a “hidden lesion” extending histologically to the pulp. It showed only as a faint line at the DEJ in the radiograph. We need methods that can detect occlusal lesions while they are still in the enamel and can be reversed or arrested by fluoride therapy and remineralization. Recently, the FDA approved a device called the “Diagnodent,” (KaVo, Ill.) which shines a red laser into the tooth via a specially designed handpiece and tip. The tip is applied to the occlusal pits and fissures individually. The red light readily penetrates the tooth; and if it interacts with a subsurface lesion that contains certain bacterial byproducts, fluorescence is produced. The fluorescent light comes back from the lesion into the handpiece, interacts with the detector, and is read out as a number and an audible signal if there is a lesion. This instrument is a good first step in providing the practitioner with a tool that can indicate whether there is a hidden lesion under the occlusal surface. Even better devices are expected to become available to detect early enamel lesions in occlusal surfaces. The future will see improvements in these and other techniques, and the tools for early detection will be available. The bottom line is that we must use early detection for the purposes of intervention, not to justify more drilling and filling.³²

Caries Risk Assessment

Practical caries risk assessment and the consequent clinical actions were the basis for the conference that generated this issue of the Journal. The importance to the pediatric dentist is that such procedures will change the way care is delivered.³³ Similarly, in a public health setting, it will change the way interventions are done and how money is spent on programs to help lower-income/high-risk populations. The basis of caries risk assessment as we are currently introducing it into the predoctoral dental teaching clinics at the University of California at San Francisco is the “caries balance” described above (Figure 1). Each of the pathological and protective factors must be assessed in coming to a judgment as to whether the patient is at risk of progression or initiation of dental caries. We have developed a form for the clinician with instructions on the back to guide in risk assessment. When the risk assessment is complete, this influences the treatment plan. If the patient is required to conduct home care, a second form with appropriate instructions highlighted is given to the patient with a prescription, if needed. The reverse side of this form has a lay-person one-page description of dental decay. The guiding principle (risk factor) questions for this risk assessment tool were as follows:

- Is there existing or has there been new untreated cavities in the past two years?
- Has there been orthodontic appliances or removable partial dentures?
- Is there reduced salivary function as

measured by stimulated saliva flow less than 0.7 ml/minute?

- Is there use of hyposalivatory medications?
- Is there frequent ingestion of fermentable carbohydrates (by questioning the patient)?
- Is current use of fluoride products inadequate? and
- Is there high caries bacterial challenge as measured by testing mutans streptococci and lactobacilli?

The number of yes answers to the above questions places the patient into one of three risk categories. If the answers to the first five questions are mostly no, then bacterial testing is not needed. If bacterial testing is needed, the Ivoclar (Amherst, NY) caries resistance test is used; and results are known in 48 hours. This forms the basis for future monitoring of the effectiveness of antibacterial therapy. If the person is at high risk, this initiates:

- Bacterial testing;
- Fluoride therapy (fluoride office topical followed by higher concentration home use fluoride is used);
- Chlorhexidine therapy (0.12 percent chlorhexidine gluconate for two weeks daily every three months); and
- Regular recall to monitor lesion progress or arrestment and antibacterial therapy success.

In the future, we anticipate that improved chairside bacterial testing and improved antibacterials will be available. For example, it is theoretically possible to design antibacterials to target receptors on the cell wall of the cariogenic bacteria involved. With new advances, these will enhance the success of the principles proposed in this presentation toward the eradication of dental caries.

Acknowledgments

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Acquisition and Transmission of Mutans Streptococci

ROBERT J. BERKOWITZ, DDS

ABSTRACT Dental caries is an infectious and transmissible disease. The mutans streptococci and some *Lactobacillus* species are the two groups of infectious agents most strongly associated with dental caries. Earlier studies demonstrated that infants acquire mutans streptococci from their mothers and only after the eruption of primary teeth. More recent studies indicate that mutans streptococci can colonize the mouths of preeruptive infants and that horizontal, as well as vertical, transmission does occur. These findings will likely facilitate the development of clinical strategies to prevent or delay infant infection by these organisms, thereby reducing the prevalence of dental caries.

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The mouth of a normal preeruptive infant contains only mucosal surfaces exposed to salivary fluid flow. Mutans streptococci could persist in such an environment by forming adherent colonies on mucosal surfaces or by living free in saliva and multiplying at a rate that exceeds the washout rate caused by salivary flow. Because the oral flora averages only two to four divisions per day¹ and swallowing occurs every few minutes, it is reasonable to assume that bacteria cannot maintain themselves free in saliva solely by proliferation, but instead must become attached to an oral surface.

Previous studies, reviewed by Gibbons and van Houte (1975),² have demonstrated that mutans streptococci have a feeble capacity to become attached to epithelial surfaces. Therefore, it seemed unlikely that these organisms could colonize the

mouth of a normal infant before the eruption of teeth. Earlier clinical studies reported that mutans streptococci could not be detected in the mouths of normal preeruptive infants³⁻⁸ but could after the insertion of acrylic cleft-palate obturators or eruption of primary teeth.

A longitudinal investigation by Carlsson³ and coworkers reported that mutans streptococci were detected in five of 25 (20 percent) infants age 12 months to 16 months. In addition, these organisms were not detected in any of the 25 subjects during their first year of life. Although Carlsson and colleagues did not report the stage of dental development, the age range of 12 to 16 months is compatible with an infant having six to 10 primary teeth. Berkowitz and coworkers⁴ reported that mutans streptococci were detected in 9 of 20 (22 percent) infants who had only primary incisor teeth. In a subsequent

study,⁵ Berkowitz and colleagues reported that these organisms were detected in 3 of 43 (7 percent) infants (mean age = 8.9 months) with one to five primary incisor teeth and 12 of 42 (29 percent) infants (mean age 13.8 months) with six to eight primary incisors. Likewise, Stiles and coworkers⁶ detected these organisms in 12 of 56 (22 percent) of infants (median age = approximately 14 months) with six to eight primary incisors and one of 38 (2.6 percent) of infants (median age = approximately 9 months) with two to four primary incisors. Catalanotto and colleagues⁷ were unable to isolate these organisms from 10 infants who had only primary incisor teeth; mutans streptococci were detected only after the eruption of primary first molars.

A more recent study by Caufield and coworkers⁸ reported that 25 percent of their infant population (n = 46) acquired mutans streptococci by 19 months of age. Extrapolation of Caufield and colleagues' data from a figure depicting the cumulative probability of mutans streptococci acquisition as a function of age indicated that approximately 5 percent of their study population acquired these organisms by approximately 9 months of age and approximately 15 percent of the subjects were colonized by approximately 12 months of age. Accordingly, the concept that mutans streptococci required a nonshedding oral surface for its persistent oral colonization became a basic tenet of oral microbial ecology. However, more recent clinical studies⁹⁻¹¹ have demonstrated that mutans streptococci can colonize the mouths of predentate infants. The furrows of the tongue appear to be an important ecological niche. Tanner and coworkers,¹² utilizing DNA probe technology, reported that mutans streptococci were found to be present in 55 percent of plaque samples and 70 percent of tongue scraping samples of 57 children age 6 to 18 months living in Saipan. These recent studies on acquisition of mutans streptococci raise doubts that a nonshedding oral surface

is required for their oral colonization.

Early Acquisition of Mutans Streptococci and Dental Caries

Early colonization by mutans streptococci is a major risk factor for future caries experience. Children were longitudinally assessed from age 2 to 4 by Alaluusua and Renkonen¹³ for mutans streptococci colonization and dental caries; those children who harbored mutans streptococci in their plaque at age 2 were the most caries active by age 4. Their mean dmfs score was 10.6 as compared with children who were colonized later who had a mean dmfs score of 3.4 by age 4 ($p < 0.005$). Similar observations were made by Kohler and coworkers:¹⁴ They observed that 89 percent of children colonized by mutans streptococci by age 2 had experienced caries lesions by age 4 and had a mean dmfs score of 5.0. In contrast, 25 percent of children who were not infected with mutans streptococci prior to age 2 had experienced dental caries by age 4 and had a mean dmfs score of 0.3. An additional longitudinal investigation¹⁵ evaluated 786 children at age 1 for caries risk factors (mutans streptococci infection, fluoride exposure, dietary habits, oral hygiene) and re-examined them at 3.5 years of age for the presence of dental caries. The presence of mutans streptococci at age 1 was the most effective predictor for caries at age 3 1/2. These observations and other published results^{16,17} clearly illustrate that early infection with mutans streptococci is a significant risk factor for future development of dental caries lesions.

Vertical Transmission

The major reservoir from which infants acquire mutans streptococci is their mothers. The evidence for this concept comes from several clinical studies that demonstrate that mutans streptococci strains isolated from mothers and their babies exhibit similar or identical bacteriocin profiles¹⁸⁻²⁰ and identical plasmid or chromosomal DNA patterns.²¹⁻²⁵ Successful infant colonization of maternally transmitted mutans streptococci cells may

be related to several factors which, in part, include magnitude of the inoculum,²⁶ frequency of small dose inoculations,²⁷ and a minimum infective dose.²⁸ A study carried out by Berkowitz and coworkers²⁶ reported that the frequency of infant infection (58 percent) was approximately nine times greater when maternal salivary levels of the organism exceeded 10⁵ colony-forming units per ml relative to the frequency of infant infection (6 percent) observed when maternal salivary reservoirs were less than or equal to 10³ cfu per ml. Suppression of maternal reservoirs of mutans streptococci clearly showed that infection of the baby could be prevented or delayed;²⁹ only three of 28 (11 percent) babies whose mothers had their mutans streptococci reservoirs suppressed by dental treatment and topical antimicrobial therapy were infected by age 23 months. In contrast, 17 out of 38 (45 percent) babies in the control group whose mothers' levels of mutans streptococci were not suppressed were infected. In both groups, the percentage of infected babies increased with age; nevertheless at age 4 fewer babies were infected in the test group than in the control group.

Horizontal Transmission

Two recent reports indicate that vertical transmission is not the only vector by which mutans streptococci are perpetuated in human populations. Mattos-Graner and colleagues³⁰ isolated mutans streptococci from groups of nursery school children (age 12 to 30 months) and genotyped the isolates utilizing primed polymerase chain reaction and restriction fragment-length polymorphism analysis. They reported that many children contained identical genotypes of mutans streptococci strains, which indicates that horizontal transmission may be another vector for acquisition of these organisms. In addition, van Loveren and coworkers,³¹ utilizing bacteriocin typing, demonstrated that when a child acquires mutans streptococci after age 5, there may be similarity between mutans strepto-

cocci strains in mother, father, and child, indicating that horizontal transmission can also occur between family members.

Clinical Significance

Knowledge regarding the natural history of an infectious disease facilitates a more comprehensive approach for prevention (e.g., yellow fever; acquired immunodeficiency syndrome). Studies by Kohler and colleagues^{14,29} (discussed previously) utilized this concept to prevent and/or reduce dental caries in young preschool Swedish children by reducing the risk for vertical transmission via suppression of mutans streptococci reservoirs in their mothers. Recent information^{30,31} indicates that horizontal transmission is another vector for acquisition of these bacteria. This finding is of importance given the socioeconomic changes in U.S. culture during the past two to three decades (for example, the utilization of day care facilities for preschool children of families where both parents are employed). In addition, recent studies⁹⁻¹² have reported that mutans streptococci may colonize the mouths of predate infants. This finding implies that the timing of intervention strategies to prevent or delay transmission should take into consideration that a nonshedding oral surface (primary teeth) is probably not a requisite for oral colonization by these organisms. Collectively, this review indicates that further clinical trials are needed to translate knowledge regarding the acquisition and transmission of mutans streptococci into clinical interventions that will likely prevent dental caries.

Summary

Dental caries is an infectious and transmissible disease. Detailed knowledge regarding the acquisition and transmission of infectious agents facilitates a more comprehensive approach toward prevention. Mutans streptococci are important organisms in the initiation and pathogenesis of dental caries. Recent evidence demonstrates that these bacteria can

colonize the mouth of predate infants and are acquired by vertical and horizontal transmission from human reservoirs. This information should facilitate the development of clinical strategies that prevent or delay infant infection, thereby reducing the prevalence of dental caries.

Conclusions

- Primary oral infection by mutans streptococci may occur in predate infants.
- Infants may acquire mutans streptococci via vertical and horizontal transmission.
- Improvements in the prevention of dental caries may likely be realized through intervention strategies that focus on the natural history of this infectious disease.

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Early Childhood Caries: An Overview With Reference to Our Experience in California

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ABSTRACT Dental caries in young children frequently appears first on the maxillary primary incisors, where the liquids ingested by the infant sucking on a bottle or breast remain pooled away from salivary flow. This so-called early childhood caries can rapidly progress to result in rampant destruction of the primary dentition. ECC can affect children from all socioeconomic classes but is most often found in children of new immigrants or those with lower socioeconomic status. The treatment of ECC is costly, and treatment relapses are frequent. Prevention and treatment of ECC focus on inhibition of the growth of oral bacteria. Strategies include reducing the frequency of exposure to bacterial substrates, as well as controlling the growth of oral bacteria. Topical antibacterials such as 10 percent povidone iodine show promise for future use in the inhibition of ECC in young children.

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Caries in children frequently manifests in a pattern of progression related to the feeding requirements of young children who suck from a bottle or breast. Early initiation of caries in infants and toddlers has been termed early childhood caries. In young children, caries can begin as soon the teeth erupt and can rapidly progress to extensive decay of all primary teeth (Figure 1). The pattern of decay in early childhood caries is related to salivary flow patterns within an infant's mouth. The mandibular incisors are protected by the tongue and bathed in saliva and thus show decay only with extremely severe caries challenge. Milk or other liquids sucked from a bottle

pool in areas of the mouth that are less exposed to salivary flow, particularly the facial surfaces of the maxillary primary incisors, where early childhood caries is first detected. As caries becomes more severe, the decay appears on the occlusal surfaces of the maxillary primary molars and then spreads throughout the mouth, which can result in an overwhelming infection with destruction of primary teeth throughout the mouth.

Cariogenicity

Studies of the cariogenicity (caries-causing potential) of infant foods show that milk has minimal cariogenicity relative to that of infant formulas and fruit juices.¹⁻³ However, by the time



FIGURE 1A. Initial stages of early childhood caries where the maxillary incisors are primarily affected.



FIGURE 1B. Extensive early childhood caries affecting all maxillary teeth and mandibular posterior teeth. The lower incisors are protected by the tongue and are caries-free.

the mandibular and maxillary primary incisors erupt, bottle or breast feeding is supplemented by a variety of solid foods. These foods include starches and other sucrose-containing foods with cariogenic potential, which provide an improved substrate to promote the proliferation of cariogenic bacteria. In addition, adding a sweetener in bottles fed to infants is a major risk factor for early caries.^{4,5} Young infants may feed from a bottle or breast six or more times per day. As the infant grows older, the number of feedings does not dramatically change, but the variety and amount of food that a child ingests increases. The frequency of feeding of infants and toddlers makes them particularly susceptible to caries. If the frequent feedings are accompanied by prolonged exposure of the teeth to liquids, as occurs when liquid is ingested from a bottle, susceptibility increases even more.⁴⁻⁸ The relative frequency with which young children feed is likely to affect the so-called "caries balance" between factors that promote demineralization and those that promote

remineralization.⁹ The frequent and prolonged introduction of cariogenic food substrates (as occurs in bottle feeding with sweetened liquids), with the subsequent lowering of plaque pH and tooth demineralization, can push the balance toward tooth demineralization. By far the most caries-promoting food substrate is sucrose;^{2,3,10} but other carbohydrates -- including glucose, fructose, and cooked starch -- also contribute.

Prevalence and Distribution

This childhood dental disease is a public health problem that affects babies, toddlers, and preschool children worldwide. The epidemiology of early childhood caries shows that disadvantaged children -- regardless of race, ethnicity, or culture -- are most vulnerable.^{11,12} Early caries in infants and toddlers also results in a higher risk for continued tooth decay as the children grow older. High-risk North American populations include children of new immigrants and children from lower socioeconomic populations. In California, the relative size of the new immigrant population is high compared with other states. Early childhood caries is particularly prevalent in this population.¹³ Mexican-Americans, who were shown in the NHANES III data to be a vulnerable population for caries in children,^{14,15} make up a large percentage of the immigrant population in California. In 1993, Serwint and co-workers found that 20 percent of the 110 Mexican-American children (18 to 36 months of age) who were patients of a hospital-based pediatric practice in Los Angeles, had early childhood caries.¹⁶ More recently, Ramos and coworkers found that in a predominantly Mexican-American population in San Francisco, 43 percent of the children younger than 5 had caries in their primary teeth.¹⁷ Native American children are at high risk for caries, with prevalence rates of early childhood caries reported from 40 percent to 72 percent.^{18,19} In 1996, George and coworkers examined 4-year-old

Apache children to determine how caries levels and patterns were different from 15 years before. Neither the caries prevalence (95 percent) nor the prevalence of caries patterns differed between the 1978-79 and 1993 cohorts. However, the level of treatment received in 1993 was greater than that in 1978-79. Studies such as this one suggest that our current effort at caries prevention, which are largely confined to caries treatment for high-risk populations, has had minimal effect in reducing the prevalence of this disease.

Etiology

The fact that caries is a transmissible disease involving the cariogenic bacteria mutans streptococci has been well-established.²⁰⁻²⁵ The major reservoir from which babies acquire mutans streptococci is their mothers or primary caregivers, though cariogenic bacteria can be transmitted from other caregivers or children in close contact.²⁶ Suppression or alteration of maternal reservoirs of mutans streptococci has shown that infection of a baby can be prevented or delayed.^{27,28} However, a single treatment of mothers with an oral antibacterial may not be sufficient to prevent mutans streptococci transmission and subsequent caries in children.²⁹ Likewise, antibacterial treatment of children may not be sufficient to reduce infection if maternal levels remain high.

Current Treatment With Reference to Northern California

The current standard of care for treatment of severe early childhood caries usually necessitates general anesthesia with all of its potential complications, because the level of cooperative behavior of babies and preschool children is less than ideal. The cost of treating a child with ECC exceeds \$2,000.³⁰ More recent data show that costs have escalated. For example, the estimated cost for facilities and general anesthesia, excluding dental services, for the treatment of a child with ECC at the University of

California in San Francisco is between \$3,700 and \$4,700. Costs may be even higher when the child has a medical condition requiring that treatment be completed in the main operating rooms. The need for treatment of children for rampant and progressing caries in California may be increasing. Early childhood caries places a huge financial burden on third-party carriers (insurance companies and state government medical welfare agencies) as well as parents least able to afford it. Studies have shown that restorative dentistry alone has little to no long-term impact on oral populations of mutans streptococci.³¹ Not surprisingly, clinical outcomes for treatment of early childhood caries are poor. Studies by Berkowitz and coworkers have shown that 53 percent (13 of 24) of children treated for early childhood caries under general anesthesia relapsed within four to six months with new smooth-surface carious lesions.³² Almeida and co-workers retrospectively evaluated 42 children treated for ECC under general anesthesia at the Franciscan Children's Hospital and Rehabilitation Center in Boston. By the end of 12 months, 19 of 42 (45 percent) of these children had relapsed with new carious lesions.³³

Prevention and Treatment

The rapidity with which early childhood caries can progress suggests that means other than the traditional approach of remineralizing incipient carious lesions through the use of topical fluoride administered either in the drinking water or in toothpastes are required. Improved clinical outcomes for treatment of early childhood caries are likely to be realized through treatments that address the infectious characteristics of this disease and place emphasis on controlling the disease dental caries as opposed to surgical treatment as an end in itself. Suppression of oral bacterial reservoirs in children should include inhibition of the transmission of mutans streptococci to children, reducing exposure of

children to fermentable carbohydrates, in particular sucrose, and developing safe and effective antibacterial approaches to reducing the number of acidogenic (acid-producing) oral bacteria in children. A variety of topical antimicrobial agents has been tested to suppress oral populations of mutans streptococci. These agents, in part, include antibiotics (vancomycin and kanamycin), stannous fluoride, the bisguanidines (alexidine and chlorhexidine), iodine, and combinations of these agents. Selection of an agent to suppress oral mutans streptococci and lactobacilli reservoirs must consider a number of factors; safety is of particular concern in babies and preschool children. Utilization of stannous fluoride is contraindicated in children younger than 4 because of the potential risk of fluorosis (Clinical Guidelines, American Academy of Pediatric Dentistry, 2000). The bisguanidines are not recommended for use in young children because of lack of information regarding safety, alcohol content, staining of teeth, and the potential for disruption of taste. The antibiotics -- vancomycin³⁴ and kanamycin³⁵ -- have very short-term suppressive effects on oral populations of mutans streptococci and have not been shown to be effective in reducing caries. One promising approach is the use of topical iodine formulations, which are approved for pediatric use and have prolonged suppressive effects on oral reservoirs of mutans streptococci. They may also suppress lactobacilli. A recent study (unpublished) in which ECC children were treated with 10 percent povidone iodine while undergoing their restorative procedures showed that mutans streptococci and lactobacilli were markedly reduced for up to three months. Details of that study will be published elsewhere. Another modality that can be used to inhibit transmission from mother to child is the use of xylitol gum or mints by the mothers during the first two years of the child's life. Studies have shown that caries in infants can be inhibited significantly in this way.³⁶

Iodine as an Oral Bactericidal Agent

Iodine is among the most potent of bactericidal agents. Its effect is not time-dependent; once bacterial contact is made, its action is immediately lethal. Iodine has excellent penetrability into dental plaques.^{37,38} These characteristics make it an excellent agent for oral use. Earlier studies by Gibbons and coworkers showed that a single two-minute application of a 2 percent iodine/potassium iodine (I₂-KI) solution eliminated mutans streptococci from accessible human tooth sites for up to 13 weeks.³⁹ In 1977, Caufield and Gibbons showed that a dental prophylaxis followed by three applications of a 2 percent I₂-KI solution significantly reduced mutans streptococci levels in fissure and proximal-surface plaques and saliva. Reductions persisted for 20 to 24 weeks in proximal plaque and saliva; fissure plaques were significantly suppressed for four weeks but gradually returned to baseline levels in the absence of dietary restrictions.⁴⁰ Recently, the influence of bimonthly topical application of 10 percent povidone iodine was assessed in a placebo-controlled double-blind clinical trial in preventing the development of white spot lesions on the maxillary primary incisors of Puerto Rican babies at high risk for developing early childhood caries.⁴¹ The study population consisted of 83 subjects (age 12 to 19 months, 40 female and 43 male). The healthy caries-free children were included in the study if they had four maxillary primary incisors with no visible defects, used a nursing bottle at naptime and/or bedtime that contained a cariogenic substrate, and had two consecutive mutans streptococci positive cultures from pooled maxillary primary incisor plaque. The subjects were randomized into two groups that were evaluated every two months during the study period. At each evaluation, the subjects had 10 percent povidone iodine (experimental group) or placebo (control group) applied to their dentition. The results of this study showed that the children

who received topical treatment with 10 percent povidone iodine were significantly more likely to remain caries-free. Collectively, the preceding information strongly suggests that topical iodine agents are efficacious for preventing dental caries in babies and young preschool children at high risk for this disease. Dr. Reed Snow, director of the Delta Dental special programs in California, has many times stated over the past several years that it is time for a paradigm shift in our understanding of caries etiology, prevention, and treatment. The use of safe and effective means to inhibit bacterial transmission subsequent infection should be at the cornerstone of this paradigm shift.

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The Role of Caries Prevention Protocols in Pediatric Dentistry Specialty Programs

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ABSTRACT Advanced specialty education programs in pediatric dentistry are often overwhelmed with patients who need restorative and surgical care, often on an emergency basis. Still, the Commission on Dental Accreditation Standards for Advanced Specialty Education Programs requires that residents receive didactic and clinical training in the prevention of dental caries. This paper contains several recommendations for strengthening the training of pediatric dental residents in caries risk assessment and prevention, including the suggestion that pediatric dental training programs become “dental homes” for their patients.

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One of the overarching goals of the pediatric dentist is to guide young patients into becoming adults who will value good oral health and seek out dental care when the responsibility becomes theirs alone. There are many aspects to this journey, but the prevention of dental disease lies at the heart of the process. Prevention has been arguably a bigger component of pediatric dental education than any other specialty, with the possible exception of public health dentistry. Despite this long history, pediatric dental programs struggle to keep up with the rapidly changing knowledge base and

technologies in the arena of prevention.

Dentistry must begin reorienting its approach to dental caries from a primarily surgical approach to a more preventive-oriented, nonsurgical, or medical-management approach. As Edelstein¹ has noted, dental caries is a steady-state disease with variable expression over time. A surgical approach to a steady-state disease is inefficient, creating a constant state of playing “catch-up.” In the broader arena of pediatric dental practice or indeed in general dental practice, change must come to embrace more effectively the new concepts of prevention and caries management by risk assessment. Stewart² has

addressed the needs and changes for the private practitioner. The aim of the present review is to specifically target changes that need to be made in programs that teach the pediatric dentists of the future. All pediatric dentistry programs recognize that preventing dental disease is less invasive, and therefore less expensive, than treating its effects. Yet the programs also must graduate individuals who are proficient at diagnosis, behavior management, space management, and a host of other skills, including the surgical management of caries. Virtually all of our programs are overwhelmed by requests for care from patients with high treatment needs, who often suffer chronic pain, and who require restorative and surgical care, often on an emergency basis. Where, then, do prevention protocols find their place in pediatric dentistry programs?

Current Standards

The Commission on Dental Accreditation Standards for Advanced Specialty Education Programs in Pediatric Dentistry³ requires that residents receive didactic and clinical training in managing dental caries. In the section on biomedical sciences, cariology is mentioned under the heading microbiology, along with virology and immunology. Instruction in those topics is to be provided at the understanding level.^a In the clinical science core, instruction is to be provided at the in-depth level^b in oral disease epidemiology, which presumably would include dental caries. Dental caries is explicitly mentioned in a later item in the clinical sciences core, though it is included with periodontal diseases, pulpal pathology, traumatic injuries, and developmental anomalies. Specifically, programs are directed to provide in-depth instruction in “the scientific basis for the prevention and

treatment of dental caries,” in “infant oral health care,” and in “the effects of proper nutrition, fluoride therapy and sealants.”

It is not possible nor even desirable for these standards to be extremely detailed and prescriptive. Clearly, however, much is taught that is not explicitly addressed in the guidelines. If residents are truly to be able to offer caries prevention programs to their patients, they need to be exposed to additional information, some at the understanding level, some at the in-depth level.

Recommendations

First, in the biomedical sciences area, residents should receive information that reinforces at the understanding level what they learned in dental school about the histopathology of dental caries. Much of the nonsurgical management of caries is based on our ability to manage white spot lesions, reduce demineralization, and enhance remineralization. In some pediatric dentistry programs, that information may be taught as part of “fluoride therapy.”

Programs should also ensure that under the topic of microbiology of dental caries, residents understand the transmissibility of mutans streptococci. They should know how and when the transmission is thought to occur and how it might be disrupted. Programs should encourage early dental visits. Our programs should adopt the age 1 year initial examination as recommended by the American Academy of Pediatric Dentistry, the American Dental Association, and the American Association of Public Health Dentists. One-year-old patients could be recruited by advising pregnant mothers of older patients, and perhaps by partnering with the departments of pediatrics and obstetrics in the programs’ parent institutions.

The latter recommendation raises the issue of prenatal counseling. Until a

few years ago, pediatric dental residents were required to participate in prenatal counseling programs. This activity was not easily arranged, so it became one of the most often cited deficiencies in program reviews. Eventually, it was dropped from the standards. Our current understanding of caries transmission, possible disruption of transmission, and the advisability of early dental visits suggests that prenatal counseling could become an important skill for the pediatric dentist. We also should be advising pregnant women of the impact that their own oral health can have on the outcome of their pregnancies. While I am not arguing for the reintroduction of prenatal counseling into the standards, I suggest that pediatric dentistry programs recognize the benefits of prenatal counseling and take advantage of these opportunities whenever possible.

The current standards do not mention early childhood caries as an entity, but this topic is likely being taught under the items on “epidemiology of oral diseases” and “infant oral health care.” We must ensure that pediatric dentistry residents have in-depth knowledge of this specific form of dental caries, including its etiologies and epidemiology.

Caries risk assessment is another concept not mentioned in the guidelines but which must be learned at an in-depth level by pediatric dentistry residents. Some programs, indeed some predoctoral dental programs, are using formalized risk assessment programs. Others are using less formal approaches. There is room for both approaches, but risk assessment must be strengthened as a foundation for the medical management of dental caries. Identifying children with the caries process prior to development of the signs of dental caries is an important skill. Residents should be exposed to the value of bacteriologic

salivary assays for mutans streptococci and lactobacilli as a means of early risk identification. Residents should also know how to intervene once such patients are identified. Further, we should ensure that residents recognize that a child with carious lesions is at an elevated risk for further disease progression. Eradication of the signs of caries by means of crowns, fillings, and extractions does not eliminate the disease process. Residents should be able to design prevention programs for their restorative patients that will lower the risk for future lesion development.

Fluoride therapy and sealants are specifically cited in the standards. Certainly our programs should be teaching safe and cost-effective use of professionally applied topical fluoride. Risk assessment should be applied to determine which patients will benefit from topical application, and which topical product -- varnish, gel, foam -- is appropriate. The same analysis should be applied to the use of systemic supplements, fluoride mouthrinses, and prescription fluoride gels and pastes. Residents should be taught the scientific basis and clinical applications of an extended range of anticaries agents, including chlorhexidine, xylitol, and any other suitable antibacterials that become available in the future.

Finally, pediatric dental programs should, to the extent possible, become "dental homes"⁴ for their patients. This is a relatively new construct in dentistry. Pediatrics, however, has long seen the value of identifying for every child a practitioner who can provide health supervision in a safe and familiar environment, the medical home. The concept of a dental home is too new to have been assessed as a predictor of dental health, but data exist to support the notion that early access to dental care might result in fewer dental emergencies and better dental health.⁵⁻⁷

Nowak and Casamassimo⁴ suggested that the dental home be accessible, family-centered, continuous, comprehensive, coordinated, compassionate, and culturally sensitive. The one characteristic that may be difficult for pediatric dental programs to fulfill is continuity, defined as providing the same primary care providers from infancy through adolescence. Attending faculty could fulfill this role to some extent. The dental home concept fits well with the emphasis on comprehensive care that exists in pediatric dentistry programs. The problem, alluded to earlier, is the demands placed on programs for emergency and episodic care. Still, if pediatric dental practices are to function as dental homes, residents should be exposed to the concept and programs should emulate dental homes to the extent possible.

Conclusion

Pediatric dentistry programs are adjusting to the shifts in preventive strategies away from the idea that dental caries is inevitable and that surgical management of the lesions may even precede attempts at prevention. We are adopting the notion that our programs and our residents should be primarily engaged in health supervision, rather than only in the treatment of disease. Under this new model, we should be teaching and practicing early examination and risk assessment. We should be providing anticipatory guidance to caregivers, enlisting them as partners in the oral health care of their children. We should be striving to provide true prevention, where possible, with programs designed to disrupt or reduce the transmission of caries-causing bacteria. Some programs have probably adopted these concepts and are involved to some extent in these activities. Others could benefit from presentations and publications of model programs.

The dental health care system is slow to change. If, however, pediatric dentistry programs embrace and teach the concepts discussed at this workshop, we could begin to see more contemporary preventive programs in use in pediatric dental homes in the near future.

Notes

- a. Understanding level: adequate knowledge with the ability to apply.
- b. In-depth level: a thorough knowledge of concepts and theories for the purpose of critical analysis and the synthesis of more complete understanding.

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Dental Disease Prevention and People With Special Needs

PAUL GLASSMAN, DDS, MA, MBA, AND CHRISTINE MILLER, RDH, MSH, MA

ABSTRACT People with special needs are the most underserved of the underserved in our society. They have more dental disease, more missing teeth, and more difficulty obtaining dental care than other segments of the population. Many individuals and groups, including the authors of this paper, have developed community-based systems to improve oral health for people with special needs. However, these systems have not been as successful as they might be because of lack of effective preventive protocols specifically designed for people with special needs. This paper reviews strategies for overcoming informational, physical, and behavioral barriers to oral health and presents a summary of the results of a conference titled "Practical Preventive Protocols for Prevention of Dental Disease in People with Special Needs in Community Settings." The rationale for using an Oral Health Care Plan is presented as well as a sample plan. These strategies and protocols are designed to complement the system of supported community-based oral health care. The goal of this system is to help people with special needs enjoy a lifetime of oral health the same as other members of our society.

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People with special needs are the most underserved of the underserved in our society. They have more dental disease, more missing teeth, and more difficulty obtaining dental care than other segments of the population.¹⁻⁶ Not only is access to dental services difficult, but treatment can be more difficult when services are obtained. Often there is inadequate attention to preventing dental disease in these populations. The combination of inadequate attention to prevention, greater disease burden, scarce treatment resources, and more difficulty in performing treatment results in pain, suffering, and social stigma in these populations beyond that found in other segments of our society.

Reports that focus on people with developmental disabilities residing in community settings have shown that these individuals have significant unmet medical needs in general,⁷⁻¹⁰ as well as significant unmet dental needs.¹¹⁻¹⁴ The situation is even worse for individuals with disabilities who are living in rural areas of our country.¹⁵ The Surgeon General's Report on Oral Health points out that populations with mental retardation or other developmental disabilities have significantly higher rates of poor oral hygiene and an increased need for periodontal treatment than the general population. In addition, people with disabilities have

a higher rate of dental caries than the general population and almost two-thirds of community-based residential facilities report that inadequate access to dental care is a significant issue.¹⁶⁻¹⁹ Untreated dental disease has been found in at least 25 percent of those with cerebral palsy, as well as 30 percent of those with head injuries, and 17 percent of those with hearing impairment.² A study commissioned by the Special Olympics concluded that the oral health of individuals with mental retardation is poorer than that of their peers without mental retardation. Individuals with mental retardation have more untreated caries and a higher prevalence of gingivitis and other periodontal diseases than those in the general population.²⁰

People with special needs residing in community residential facilities are dependent upon community-based sources of dental preventive and treatment services in greater numbers than ever before. In the mid 1970s and since, as a part of the de-institutionalization and normalization process, almost two-thirds of those individuals residing in institutional settings were moved into community-based settings. Unfortunately, the dental care services received in institutions are often unavailable once these individuals are moved into the community.²¹ Therefore, de-institutionalization has exacerbated the problem that many individuals with special needs have

in obtaining access to dental care as they move from childhood to adulthood. Availability of dental providers trained to serve special needs populations and limited third-party support for the delivery of complex services further complicate the issues entailed in addressing the needs of these populations.¹ There are even some that believe that the health care system in the United States practices active discrimination against people with disabilities for no other reason than because they have a disability that makes the health care professional uncomfortable.²²

People with developmental disabilities are served in California by a network of private agencies referred to as Regional Centers. These centers contract with the California Department of Developmental Services to provide a local resource to help find and access the many services available to individuals with developmental disabilities and their families. Individuals with developmental disabilities are referred to as “consumers” of the Regional Center services. In 1998, working with the Department of Developmental Services, the University of the Pacific School of Dentistry took a leadership role in starting a Statewide Task Force on Oral Health for People With Special Needs. This task force has brought together diverse dental and social service organizations and individuals to foster communication, collaboration, and advocacy to improve oral health for people with special needs. One activity of this task force was the 1999 assessment of needs and resources for people with developmental disabilities in California.²³ Data was collected through surveys of 139 staff members from 14 Regional Centers serving 89,000 consumers, a sample of 538 consumer surveys and oral health screenings, and surveys of 320 dental professionals. Among the many findings was the fact that there were inadequate resources in the Regional Center system for identifying oral health problems, making referrals, or tracking treatment outcomes. There were few organized preventive education programs. Consum-

ers reported multiple problems finding dentists willing to treat them and accessing the limited services that were available. Oral health screenings revealed that 80 percent of those screened had current dental disease and yet 60 percent reported that they were unaware of any dental problems. Finally, the dental professionals surveyed reported that they did not feel that they were adequately trained to provide the care needed by this population. These findings are consistent with those reported above, again demonstrating the mix of ubiquitous dental disease, inadequate treatment resources, and the absence of an organized prevention system.

People with special needs who are having difficulty obtaining treatment and preventive dental services also include the nation’s growing frail senior citizen population. An estimated 70 percent of the nation’s 2 million plus nursing home population has dental problems that include dentures that don’t fit and loss of some or all of their teeth, but most significantly poor oral hygiene.²

People with special needs or their caregivers may have limitations in the understanding of and physical ability to perform personal prevention practices or to obtain needed services.¹ Some oral problems are exacerbated by associated medical problems or the side effects of medication, or caused by the disability itself.

Many individuals and groups, including the authors of this paper, have developed community-based systems to improve oral health for people with special needs.^{11,24-31} The programs developed by the authors have included activities to build community coalitions, develop triage and referral systems, train community oral health professionals, develop sources of outpatient and hospital dental services, and develop and implement community-based prevention programs. They have used the services of a dental coordinator, typically a dental hygienist, who has acted as a “dental case manager” and liaison between community social service agencies and local oral health professionals.

As a part of the community-based system just described, the authors have developed prevention training materials and demonstrated their effectiveness in improving caregiver knowledge and participation in prevention practices. They have also demonstrated the effectiveness of these materials in teaching dental and dental hygiene students about considerations for improving the oral health of special needs populations.³²⁻³⁴ These materials -- which include a videotape, workbook, and trainers manual -- incorporate information about oral health and disease, oral hygiene practices, and behavioral interventions. There is an emphasis on developing an individual oral health plan for each individual. There is, in addition, information about the use of chemotherapeutic agents as part of an oral hygiene regimen. However, at the time that those recommendations were developed there were not clear, practical protocols available in the literature that were agreed upon by groups of experts and that could be applied in community settings. Also, many of the new preventive strategies depend upon the ability of the individual to be evaluated and treated in a dental office or to cooperate for certain professionally applied therapies. This is not always possible for people with special needs.

The lack of practical protocols for the prevention of dental diseases in community settings, along with limited reimbursement for these preventive practices and regulatory barriers to their use, was the major motivation for a conference.

The Conference

The conference titled “Practical Preventive Protocols for Prevention of Dental Disease in People With Special Needs in Community Settings” was held in February of 2002 at the University of the Pacific School of Dentistry. This conference was supported by a grant from the state Department of Developmental Services Wellness Program and administered through the Redwood Coast Regional Center. Expert panelists were invited to review

the literature and present information on various preventive protocols. Table 1 lists the experts and their topic areas. There was also a panel of reactors, listed in Table 2 who commented on the expert panel presentations and participated in the development of the protocols.

The premise for the conference was that regular professional oral health care, plaque and diet control, fluoridated water supplies, and professionally applied sealants are all widely accepted measures to prevent dental diseases.^{1,35} Other methods of preventing dental disease are less widely used or accepted. Although there have been several decades of research on the use of chemotherapeutic agents, they are not widely used in the practice of dentistry.¹ A number of these interventions could be used in community settings and may not require the use of a dental office setting. One of the reasons that these measures are not used more broadly is the lack of practical protocols for their use, particularly in community settings. It is clear that confining treatment and prevention modalities to use in dental offices will not be effective with populations of people with special needs who have difficulty accessing dental office treatment. Therefore, it was believed to be critical to develop interventions that do not require a dental office setting.

The complete results and background papers for the conference described above will be published elsewhere, but the major findings are summarized in the recommendations listed below. The recommendations described here also include guidelines included in the preventive training package called *Overcoming Obstacles to Dental Health: A Training Program for Caregivers of People With Special Needs*.³⁶

The conference described above and this paper use the term "people with special needs" to describe people who have difficulty accessing dental treatment services because of complicated medical, physical, social, or psychological situations. The broad category of "people with

Table 2.

Reactor Panel for the Conference on the Development of Practice Preventive Protocols for Prevention of Dental Disease in People With Special Needs in Community Settings

Reactor

Sandra Hammersmark, RN, BSN

Nurse consultant
Harbor Regional Center
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Robert Isman, DDS, MPH

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special needs" encompasses a wide variety of individuals with different abilities and living situations. The emphasis is on individuals who may have trouble fully following traditional oral health recommendations for control of plaque, who may not be able to rinse and spit out oral solutions, and who may need assistance carrying out preventive recommendations.

The focus of the recommendations contained here is on measures that can be applied in "community" settings

including individual and family homes, residential care facilities, day work and treatment centers, skilled nursing facilities, hospitals, and other settings outside of a dental office or clinic. The focus on community settings is considered essential because effective long-term prevention must take place primarily outside of dental offices or clinics, and many people with special needs have difficulty accessing dental offices or clinics.

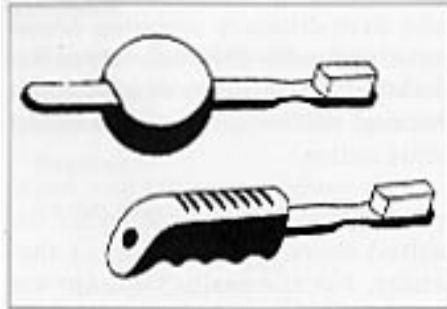


FIGURE 1. Toothbrushes adapted for easier grip (Copyright UOP School of Dentistry. Reprinted with permission).



FIGURE 2. Adapted toothbrush for someone with limited dexterity (Copyright UOP School of Dentistry. Reprinted with permission).

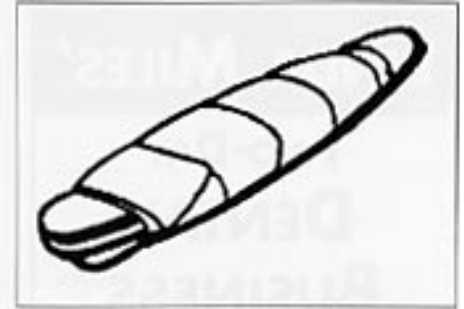


FIGURE 3. TA tongue blade mouth prop (Copyright UOP School of Dentistry. Reprinted with permission).

Prevention Recommendations for People With Special Needs

Overcoming Barriers

Barriers to prevention of dental disease for people with special needs can be classified into three types: informational, physical, and behavioral.³⁶ As described in the *Overcoming Obstacles to Dental Health* training materials, informational barriers include a lack of understanding among individuals and their caregivers about effective practices to prevent dental disease. Since people with special needs can be dependent upon someone else, a caregiver, to help them carry out preventive practices, it is critical that both the individual and his or her caregiver understand the causes and techniques for prevention of dental disease. It is not likely that a caregiver will do more for the individual they are caring for than they will do for themselves. Therefore caregivers must understand the importance and benefits of oral preventive practices as well as the techniques to accomplish them. Whether the caregiver is a direct-care staff member in a community residential care facility, a licensed vocational nurse in a nursing home, or a parent of a child living at home, he or she can be mo-

tivated by the knowledge that good oral health is a part of good general health, that good oral health can make an individual more independent in other areas of their lives, and that maintaining good oral health can make the life of the caregiver more pleasant as well as the life of the individual he or she is caring for. Dental professionals can have an important role in passing on this information in dental office settings, community preventive presentations, and in-services in institutional care settings. Specific information about application of chemotherapeutic interventions will be addressed in the section on the medical model below.

Another barrier to prevention of dental disease is physical. Some people have the understanding about what needs to be done, but lack the musculature, dexterity, or coordination to do it. There are numerous adaptations and aids that can help overcome these physical barriers. Figure 1 shows toothbrushes that have been adapted with a larger handle using a tennis ball or bicycle handle grip. Figure 2 shows someone with limited dexterity using a large foam ball as a means of picking up a toothbrush. Similar adaptation can be made for floss holders.

A general principle in working with

people with special needs is that they should be encouraged to do as much as possible for themselves. However, if they have limited ability to perform oral hygiene procedures, they may need help from a caregiver to complete those procedures. This is referred to as “partial participation.” There are several positioning techniques that can make it easier for a caregiver to help someone complete oral hygiene procedures. Figure 3 is an illustration of a “tongue blade mouth prop.” This type of mouth prop can be easily constructed by a caregiver from readily available materials and can be very useful in helping someone complete oral hygiene procedures. Figure 4 shows the use of a tongue blade mouth prop with someone who is sitting on the floor with their head resting on the caregiver’s shoulders. Note the use of the forefingers of the left and right hand in stabilizing the head. Figure 5 again shows the use of a tongue blade mouth prop. This time the individual may be less able to help and is positioned on a couch. Note the use of the right forearm and the tongue blade in stabilizing the head. These positions allow the caregiver to see and gain access to parts of the mouth that would be difficult in other positions. Again, dental profes-

sionals can play a pivotal role in educating caregivers about the use of physical adaptations and partial participation.

Finally, there are behavioral obstacles to preventing dental disease. People can be resistant to performing oral hygiene practices for a variety of reasons. Behavioral obstacles can be overcome using one of several behavioral intervention techniques. These techniques include:

- **Structuring the environment:** This refers to picking a place or time of day that is more conducive to gaining cooperation than other times or places. It may be a place or time that reduces distractions, removes unpleasant associations to oral hygiene procedures, or makes oral hygiene procedures seem fun.
- **Involving the individual:** People with special needs, especially in group living or institutional living arrangements, may have very regimented lives. They may be told when to wake up, when to eat, when to use the bathroom, what to wear, and what they will do during the day. Anything that a caregiver can do to increase choices can aid cooperation. This can be as simple as being able to choose when to brush one's teeth or what color a new toothbrush will be. It also involves paying attention to how someone is doing and not pushing them so far so that a pleasant oral hygiene session turns into an unpleasant one.
- **Using reinforcers:** We all respond to things that are rewarding to us by wanting to continue or increase the activity that produced the reward. Carefully applied rewards can motivate people to become more and more independent in oral hygiene practices. It is important to use things that are actually rewarding for the individual and to monitor the effect of the reward over time and change it if necessary. Caregivers can be educated to realize that social rewards like smiling and praise can be as powerful for people with special needs as they



FIGURE 4. Partial participation -- using positioning and a tongue blade mouth prop (Copyright UOP School of Dentistry. Reprinted with permission).



FIGURE 5. Partial participation -- using positioning and a tongue blade mouth prop (Copyright UOP School of Dentistry. Reprinted with permission).

can for everyone else.

- **Shaping:** Shaping is the reinforcement of an approximation of the task. If you would like someone to brush for five minutes, you might use a reinforcer after 30 seconds at first. Later the reinforcer might not be used until one or two minutes have passed. It is also critical to make sure that each session is a pleasant one and ends with the individual having a good feeling about themselves and their oral health.

Dental professionals can have an important role in educating caregivers about behavioral interventions. More information about the techniques described above can be found in the *Overcoming Obstacles to Dental Health* training materials.³⁶

The Medical Model

The use of chemotherapeutic agents to prevent dental disease has been referred to as the medical model of dental prevention and is reviewed in other articles in this Journal and the issue to follow. These agents may need to be used differently with people with special needs than with other individuals. As described above, these differences are the results of the need to have protocols that can be used with people who may have trouble fully following traditional oral health recommendations for control of plaque, who

may not be able to rinse and spit out oral solutions, and who may need assistance from third parties in carrying out preventive recommendations. In addition, protocols for use with special needs populations must be able to be applied outside of the dental office in community settings.

The expert panelists who were part of the conference titled "Practical Preventive Protocols for Prevention of Dental Disease in People With Special Needs in Community Settings" described above developed the following recommendations:

- People with special needs should follow certain traditional and widely accepted preventive measures as much as possible for that individual. These fundamental practices include:
- Use of a fluoridated toothpaste accepted by the Council on Dental Therapeutics of the American Dental Association. After the age of 12, or when a dental professional finds that gingivitis is present in an individual younger than 12, use a fluoridated toothpaste accepted by the American Dental Association Council on Dental Therapeutics that contains an approved effective antigingivitis agent;
- Effective removal of bacterial plaque using a soft manual or mechanical toothbrush and dental floss;
- Daily use of fluoridated water for

Table 3.**The Oral Health Care Plan****Overcoming Obstacles to Dental Health**

Name _____ Caregiver Name _____ Date _____

Assessment

- a. Physical problems with oral hygiene: _____
- b. Behavioral problems with oral hygiene: _____

Physical Skills and Aids

- a. Skills being learned: _____
- b. Special aids: adapted toothbrush adapted floss holder electric toothbrush
- c. Schedule for using disclosing tables: _____

Plan for Partial Participation (not needed - person is independent)

- a. Best position for assisting with oral hygiene: couch, bean-bag chair, other: _____
- b. Techniques and/or aids used by caregivers: mouth prop, floss holder
- c. What part does caregiver perform: _____

Plan for Structuring the Environment

- a. Oral hygiene time and place: _____
- b. Are infection control procedures being used: _____
- c. Who will work with the individual: a.m. _____ p.m. _____

Plan for Engaging the Client

- a. Choices being offered: _____
- b. Limits the client can set: _____

Plan for Reinforcers

- a. What reinforcers are being used currently (e.g., music, book, TV): _____

Plan for Shaping

- a. What steps are being taught: _____
- b. What levels of prompts is current being used?
 Physical (hand-over-hand), Physical (touch), Pointing, Verbal

Other Prevention Actions

- a. Xylitol: 5 minute exposure 3 x/day. Form being used _____
- b. Fluoride varnish: Applied 2 x/year. Next time: _____ Applied 3 times in one week 1 x/year. Next time: _____
- c. Fluoride rinses: Person rinses and empties mouth, Caregiver uses swab technique
- d. High concentration fluoride toothpaste or gel: How and when to apply _____
- e. Chlorhexidine: Person rinses and empties mouth, Caregiver uses swab technique
- f. Diet: Decrease exposure to sugar and starches: How _____

Professional visits and recommendations

- a. Last dental cleaning appointment: Date _____ Next appointment date: _____
- b. Next dental check up or treatment appointment: _____

drinking and cooking. This may require the use of bottled fluoridated water where the community water supply is not optimally or adequately fluoridated;

- Adopting a healthy diet with an emphasis on reduction of fermentable carbohydrates intake, especially between meals;
- Regular professional oral health care including the use of professionally applied topical fluorides and pit and fissure sealants; and
- Controlling systemic factors that may affect oral health such as cessation and prevention of smoking and use of tobacco products and adequate treatment of systemic diseases that affect oral health such as diabetes.
- Use products containing xylitol (at least 50 percent by weight) as the predominant sugar with three exposures per day and five minutes per exposure. If xylitol-containing chewing gum can be used, it should be chewed for five minutes three times a day. Chewing may need to be supervised to ensure that the required exposure is achieved. For individuals who cannot chew gum, or where supervised gum chewing is not feasible, other xylitol-containing food products should be substituted. For infants, there are delivery systems that use pacifiers with a xylitol reservoir where a xylitol solution can be placed or traditional baby bottles with xylitol containing solutions. For other individuals, dissolving a xylitol-containing lozenge, mint, or lollipop can achieve the desired exposure.
- Apply fluoride varnish using one of the following regimens. The panel recognizes that the use of fluoride varnish requires some removal of food debris by brushing or wiping off the teeth prior to application. There may be some individuals or circumstances where this is not possible. The selection of the regimen should be based on the feasibility of following that regimen for a given individual.
- Apply fluoride varnish three times in

one week (e.g. Monday, Wednesday, and Friday), once per year.

- Or, apply fluoride varnish once every six months.
- For individuals who are not able to fully use the primary preventive interventions described above or for those with persistent decay in spite of the above therapies, fluoride-containing rinses can be of benefit to prevent dental caries. Even if individuals are able to fully use the three primary preventive interventions described above, fluoride-containing rinses may provide an additional source of topical fluoride. Fluoride mouthrinse is currently an optional preventive choice for all people older than 6 who can safely rinse and expectorate without ingestion. Fluoride of 0.05 percent NaF₂ has proven anticaries effects, and these effects are additive to the use of fluoride-containing toothpaste. Use a fluoride rinse product that contains 230 ppm fluoride without alcohol. Rinse for one minute twice a day.
- If an individual cannot rinse or spit out the solution, then apply the solution with a cotton swab or sponge applicator (Toothette) twice a day. Although the available evidence has not proven that there is an additive effect when 0.05 percent NaF₂ fluoride rinse is used with a fluoride varnish, such an effect has been demonstrated when used in conjunction with fluoridated toothpaste. A dental professional should be involved in the decision to add fluoride rinses as an intervention for a particular individual if the individual is younger than 6 and/or is unable to rinse without ingestion.
- The use of high-concentration fluoride toothpaste or gel should be considered for individuals where the previous recommendations are not working to adequately prevent dental caries or there is reason to believe that they will not work. One such circumstance could be an individual with xerostomia (dry mouth) resulting

from medications, radiation treatment that involves the salivary glands, or other causes. The decision to use these products should also consider the ability of the individual or caregivers to supervise and control the application of these products since they contain concentrations of fluoride that could be toxic if sufficient quantities are ingested. Typically these products contain 5,000 ppm of fluoride; and the recommendation is to brush with the toothpaste or gel before going to sleep at night, spit out the excess, and leave the residual toothpaste or gel on the teeth while sleeping. Water should not be used to rinse out the excess nor should water be consumed for one hour after use of the gel or toothpaste.

- Because of the considerations just listed, a dentist should be involved in the decision to add high-concentration fluoride toothpaste or gel as an intervention for a particular individual.
- For individuals who are not able to fully use the primary preventive interventions described above or for those with persistent decay in spite of those therapies, using a chlorhexidine rinse can be of benefit to help prevent dental caries. Rinse with a half-ounce of chlorhexidine solution for one minute twice a day for two weeks. Repeat this four times a year.

If an individual cannot rinse or spit out the solution, then apply the solution with a cotton swab or sponge applicator (Toothette) twice a day. Because it is not clear that there is added benefit from this procedure for individuals who are able to use the primary protocols listed here, a dentist should be involved in the decision to add chlorhexidine rinses as an intervention for a particular individual.

Since chlorhexidine is more effective at reducing levels of caries-producing microorganisms than is xylitol, for some individuals an initial course of chlorhexidine may be indicated prior to instituting a long-term regimen of xylitol exposure.

It should be remembered that

chlorhexidine has several side effects, including diminution of taste and staining of oral tissues, that make it less desirable than some of the other agents described above, especially for individuals who may need long-term therapy.

The Oral Health Care Plan

Many people with special needs, particularly those in group and institutional living situations, have numerous caregivers who may be helping them maintain oral health. It is critical that these caregivers understand the strategy being employed for that individual and coordinate their efforts. It is also helpful, even when the caregiver is a parent of an individual living in a family home, to have a specific plan for maintaining oral health. Figure 6 is an example of such a plan.³²

There are several advantages to using a planning and communication document such as the one in Figure 6. First, it serves to help caregivers organize their thinking about the treatment and preventive measures that are to be used for a particular individual. It helps them to think about specific interventions and measures that address the specific needs of that individual. Second, it acts as a communication vehicle so multiple caregivers can be kept up to date about the current strategies being used. Finally, it acts as a record of progress. If it is periodically updated, then caregivers can look back at old plans to review progress and use the sections of the current plan that act as reminders of future appointments or interventions.

Summary

People with special needs have the most dental disease and the least access to treatment services of any segment of our population. Therefore, it is critical that everything possible be done to prevent the occurrence of dental disease in these individuals. This article has reviewed strategies for overcoming informational, physical, and behavioral barriers to maintaining oral health. In addition, a summary has been provided of the results

of a conference titled "Practical Preventive Protocols for Prevention of Dental Disease in People With Special Needs in Community Settings." These strategies and protocols are designed to complement a system of supported community-based oral health care. The goal of this system is to help people with special needs enjoy a lifetime of oral health the same as other members of our society.

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Don't Make Me Take off My Belt

Robert E.
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We gotta get rid of air turbine handpieces. They're ruining dentistry. This is the opening prong of our campaign to return our profession to the more relaxed state we enjoyed before speed became our *raison d'être*. We need to get back to those belt-driven Doriot handpieces. Anybody can cut a full crown preparation in 10 minutes or less with a coarse diamond revolving at 400,000 rpm. Where's the challenge, the excitement in that? You touch a button on the floor with your foot, the handpiece whines in response, lights its own way, and sprays its own coolant. All you do is guide it for a few minutes.

Now you take the Doriot -- a true piece of machinery if there ever was one. It had an appeal similar to Monster Truck Bashes and Demolition Derbies. Wheels, belts, pulleys, articulated connections and an honest-to-God electric motor that put out a solid 4,000 rpm, it commanded your attention. It was activated by a 40-pound rheostat the size of a toaster oven that took at least a size 11 1/2 brogan to kick-start into position.

Nor was there that annoying wussy whine you have to put up with from an air turbine as it slowly destroys your auditory nerves. The Doriot had a satisfying whirr and clatter as the endless belt raced over its three or four sets of wheels. When you put that green stone or that stainless steel bur into that gear-driven contra-angle and

got the whole thing going flat out against human enamel your mind was engaged. You were one concentrating dentist and your assistant was on full red alert, squirting water artfully on the tip of the bur or stone to allay the smoke and odor of burning feathers that ensued.

The Doriot wasn't so picky about lubrication. A can of Three-In-One oil bought at your local Piggly-Wiggly would last for months. An important aspect of the assistant's job was regularly applying generous amounts of the oil to the wheels to prevent them from seizing. Assistants got very adept at diplomatically explaining to patients why a black streak would suddenly appear on their clothing after a freshly lubricated Doriot laid down tracks that defied any known detergent to eradicate.

In contrast, the air turbine doesn't fully engage the dentist's mind because it doesn't threaten to fly apart at any moment. It's a useful tool, but not very exciting. With no sense of impending disaster to demand full attention to its operation, comes a complacency that engenders boredom. Connected to its power source by a length of black tubing, it lacks the one thing that made the Doriot an instrument of everlasting fascination to young and old alike. It lacks a belt.

Every operator of a Doriot handpiece recalls the endless enjoyment he experi-

enced with the belt. It was a closed-circuit cord made out of some woven material that -- when carefully threaded over the wheels, under the pulleys and properly tensioned -- connected the powerful electric motor with the end of the handpiece. A skilled practitioner could accomplish this handily in somewhat less than an hour.

The thrill of witnessing a fully functioning Doriot in full chat was shared by the patients who stared transfixed as the belt whirled around its circuit much like the 33 cars that start the Indy 500. And just like the Indy track does to the racer, after a certain number of laps, the wheels would take their toll on the cord. The cord would begin to fray. Slightly at first, then with gathering authority until a considerable wad of failing cord would refuse to pass between one of the wheels and its guard. This guaranteed a mandatory pit stop until a new cord was installed. It gave the patient time to get his eyes back into some kind of focus because he had been following the disintegration of his nemesis with horrified fascination.

Pedodontists of the era took advantage of this hypnotic effect of a belt decomposing. They would wrap a little absorbent cotton around the belt in two separate places. With a little moppet in the chair, the dentist would instruct him to "watch the rabbits race." And race they did! Two bits of cotton chasing each other at speeds ap-

proaching Mach 1 were enough to enthrall the most intractable kid.

Try that with your air turbine! And don't get me started on lasers.

Alas, at last count there were only 37 dentists still alive who recall clearly the Doriot handpiece. Should you ever encounter an old party without any hair on the back of his wrist, you've stumbled on a genuine artifact. Cherish him.