OF THE CALIFORNIA DENTAL ASSOCIATION

Journal

JULY 2007

ESTHETIC CASE MANAGEMENT

EDMOND R. HEWLETT, DDS

OF THE CALIFORNIA DENTAL ASSOCIATION
Journal
CDA Journal
Volume 35, Number 7
JULY 2007

DEPARTMENTS

FEATURES

CDA JOURNAL, VOL 35, Nº7

The Making of Sausage

ALAN L. FELSENFELD, DDS

After the completion of dental school, general practice residency, or specialty training, most of us settle into a private practice of dentistry. At that point, we become comfortable in what we do for a living. Our expertise increases with experience; we can do what we like to do in dentistry, and not do what we do not like. We get to treat many wonderful patients, we make a comfortable living, and we have fun at work. Life is good.

For many of us this is idyllic. The comfort level is good, as is the control of our environment. For others, it is possible we reach a state of ennui. We begin to wonder if there is anything else to do. Can we continue to practice for the rest of our lives? Are we capable of anything else besides dentistry as a career? Can we contribute or give back in any other manner? Many of us go through similar introspective analysis from time to time.

There are numerous ways we can show our "stuff" outside the office. Many of us get involved in community service in the delivery of health care to underserved groups. For others, church and community service activities, or social involvement allow us to express ourselves in different venues. Those of us who are deeply involved in dental politics are yet another group trying to contribute at a different level.

Otto von Bismarck has been quoted as saying "Laws are like sausage, it is better not to see them being made."

The Walter Mitty in me says I feel there might be more to life than practicing dentistry. My fantasy is to be a legislator in the state assembly or senate. Can you image the responsibility and power these individuals possess? They govern our state, supposedly between the sixth and 10th largest economy in the world, as they make the laws we use to guide our lives. The ability to impact the people of our state and the direction they can provide is impressive. The committees to hear proposed legislation, testimony, and debate are all part of a process that makes this a democracy. Even party politics, which at times can be a difficult thing, can have positive rewards when it is perceived as the correct approach to a matter. What a way to have legacy in this world.

I would like to be a legislator. I would not like to become a legislator. Otto von Bismarck said "Laws are like sausage, it is better not to see them being made." This analogy can be carried over to the process of getting elected to a position. Running for office is most difficult. The people who do this have to deal with constant fund raising by attending luncheons, dinners, and cocktail parties. You must be vigilant and watch every word you say as you could be misquoted. Having to deal with special interest groups, especially when you disagree with their cause, has to be tedious. You are constantly in the public eye and may find it difficult to relax even in your own community. Couple this with the need to run for re-election on a regular basis and the increasing tendencies for "dirty" political campaigns, and one can understand the negative aspects of the election process.

We are fortunate to have colleagues who have accepted that challenge and became legislators. All of us know of the accomplishments of Sen. Sam Aanestad and Assemblyman Bill Emmerson. They have represented Californians and dentistry well. There are others, such as Sam Wakim, who seek a seat in state government in a contemporary election. Some dentists are achieving success at the

local level in municipal governments and on school boards with the possibility they can advance their political careers in time.

At a recent American Dental Association legislative leadership conference, we mourned the recent passing of Charlie Norwood, a dentist who represented all of us well in Congress. Several senators and representatives encouraged us to be involved nationally to have input into our profession.

We need to support those who can rise to this level of participation. It is important to encourage more individuals who have the desire to be involved with politics, not only at the association level, but also in local, state, and national positions. Offer them financial help as you can, for campaigning is impressively costly. Vote for them if you are in their district. Hosting coffees and other receptions will be beneficial. Helping in their campaign offices stuffing envelopes, making telephone calls, and distributing literature are all part of the workload that needs to be completed.

Those of us who become legislators are people who have given up their dental practices to move to a more global level of politics. They do well for themselves and they do well for dentistry. They serve dentistry well and show dentists can contribute back to the community. We need to continue to support such individuals and we will all be better served by doing so. I will never become a legislator, and that might be a good thing. But I am grateful that we have many friends who represent our interests well. ■■■■

Address comments, letters, and questions to the editor at alan.felsenfeld@cda.org.

The High-performance Dentist

BY DEBRA BELT

If stress is too high or too low, performance goes down.

This basic principle was at the heart of a presentation by Ben Bernstein, PhD, a performance psychologist and speaker at CDA Spring Scientific Session in May.

More than 200 dental professionals turned out to listen to Bernstein, a performance psychologist who coaches people in "high-stress, high-performance jobs," including professional athletes, opera singers, dentists, instrumentalists, attorneys, actors, physicians, business executives, and students taking tests that will shape their lives. Bernstein said dentists fall into this category because they often deal with people who are afraid, which makes things difficult. Bernstein is on the ADA's national speaker's circuit and is a consultant to the University of California, San Francisco, School of Dentistry.

CONTINUES ON 470

Zimmer Contour Ceramic Abutment

Zimmer Dental Inc. announced the launch of the Zimmer Contour Ceramic Abutment. Engineered to work with the Tapered Screw-Vent Implant System, the Zimmer Contour Ceramic Abutment provides a natural-colored base for an esthetic, all-ceramic crown.

Crafted from high-strength zirconia material, it is natural looking and contains no visible metal margins. For more information, go to www.zimmerdental.com or call (800) 854-7019.

Creation ZI-F

Willi Geller has brought onto the market a new, aesthetically altered zirconium oxide ceramic. Creation ZI-F has an extremely high feldspar content – for light dynamics equivalent to natural teeth – and is exceptionally versatile. It is suitable not only for veneering all kinds of zirconium oxide frameworks, but also as a layering material for the pressable ceramic Creation CP ZI. Its high durability and light conductivity with zirconium oxide is another bonus: The new veneering system is also impressive because of its uncomplicated handling. For more information, go to www.creation-willigeller.com.

ADA Legal Division Updates Antitrust Publication

In an effort to keep member dentists and tripartite societies aware of antitrust developments, the ADA's Division of Legal Affairs has updated its publication *Antitrust Laws in Dentistry.*

It is important for dentists to have some grounding in the antitrust laws to protect against taking on undue legal risk when it comes to issues such as fee setting and practice mode," according to the publication. "Dentists with baseline knowledge of antitrust have an added arrow in their quiver when playing the game of competition."

The antitrust primer is available online as a member benefit, in PDF format, at www.ada.org/goto/antitrust. For more information about this resource call the ADA toll-free, 800-621-8099, ext. 2874.

"Our research emphasized one of the benefits of having periodontal therapy for patients with diabetes."

KAZUO SONOKI, MD, PHD

Patients With Type 2 Diabetes Helped by Periodontal Therapy

Researchers from Kyushu Dental College in Kitakyushu, Japan, investigated the impact of periodontal therapy on patients with Type 2 diabetes, as compared to nondiabetic patients, and found that periodontal therapy decreased lipid peroxide, an oxidative stress index, in diabetic patients.

In their study that appeared in the November issue of the *Journal of Periodontology*, patients with Type 2 diabetes and periodontal disease who receive periodontal therapy see levels of oxidative stress, a condition in which antioxidant levels are lower than normal, reduced to the same levels as nondiabetic patients.

"Our research emphasized one of the benefits of having periodontal therapy for patients with diabetes," said one of the study authors, Kazuo Sonoki, MD, PhD, at Kyushu Dental College. "However, this was just a preliminary study and more research should be conducted to evaluate how periodontal disease affects both people with and without diabetes."

It has been found that periodontal disease and diabetes can lead to atherosclerosis. It has been thought that oxidative stress is linked to heart disease because oxidation of LDL (low-density lipoprotein) in the endothelium is a precursor to plaque formation. Recently, oxidative stress has emerged as an important factor for atherosclerosis in patients with diabetes.

"We hear every day about how more and more people are being diagnosed with diabetes," said Preston D. Miller, Jr., DDS, and president of American Association of Periodontology. "This research confirms that patients with diabetes should be especially conscious of their periodontal health."

Zimmer One-Piece Implant Now Available in 4.7 mm Diameter

→

Zimmer Dental Inc. announced the addition of the 4.7 mm diameter Zimmer One-Piece Implant in straight and angled versions. Also available in 3.0 mm and 3.7 mm diameters, the Zimmer One-Piece Implant combines the design features of the renowned Tapered Screw-Vent Implant with the prepared margins of the Hex-Lock

Contour Abutment, offering a unique one-piece solution for fast, convenient immediate restoration with minimal or no abutment preparation. For more information, go to www.zimmerdental.com or call (800) 854-7019.

UPCOMING MEETINGS

2007	
June 27-July 1	Academy of General Dentistry Annual Session, San Diego Convention Center, 888-243-3368.
Aug. 4	31st Annual Scripps Symposium on Oral Medicine, San Diego, scripps.org/conferenceservices, 858-587-4404.
Aug. 22-24	International Society for Breath Odor Research Seventh International Conference, Chicago, Bill Bike, billbike@uic.edu or 312-996-8495.
Sept. 27-30	American Dental Association 148th Annual Session, San Francisco, ada.org.
Nov. 27-Dec. 1	American Academy of Oral and Maxillofacial Radiology 58th Annual Session, Chicago, aaomr.org.
2008	
May 1-4	CDA Spring Scientific Session, Anaheim, 800-CDA-SMILE (232-7645), cda.org.
Sept. 12-14	CDA Fall Scientific Session, San Francisco, 800-CDA-SMILE (232-7645), cda.org.
Oct. 16-19	American Dental Association 149th Annual Session, San Antonio, Texas, ada.org.

To have an event included on this list of nonprofit association continuing education meetings, please send the information to Upcoming Meetings, CDA Journal, 1201 K St., 16th Floor, Sacramento, CA 95814 or fax the information to 916-554-5962.

Specification Approved for Shipping and Storing Dental Amalgam Waste

The American National Standards Institute has approved ANSI/American Dental Association Specification No. 109 for Procedures for Storing Dental Amalgam Waste and Requirement for Waste Storage/Shipment Containers as an American National Standard.

The specification was developed by the ADA Standards Committee on Dental Products, with representation that included the Environmental Protection Agency.

The ADA said one of the purposes for the specification is to encourage amalgam recycling by making it more effective and easier for the dental office. The specification describes procedures for storing, and preparing amalgam waste for delivery to recyclers or their agents for recycling. In addition, it gives requirements for storing and/or shipping amalgam waste, according to the ADA.

The ADA recommends that dental offices use this specification in conjunction with the ADA's Best Management Practices for Amalgam Waste. Additionally, the ADA recommends dental offices select a recycler whose procedures comply with ANSI/ADA Specification No. 109.

ANSI/ADA Specification No. 109 for Procedures for Storing Dental Amalgam Waste and Requirements for Dental Amalgam Waste Storage/Shipment Containers is available through the ADA catalog at www.adacatalog.

Biotene Denture Grip

Biotene Denture Grip is the latest innovation for denture wearers suffering from dry mouth. Without enough saliva to provide adequate adhesion, gum tissue contacting the denture may become chafed, irritated, and infected due to daily wear and harmful bacteria production.

Biotene Denture Grip was specially formulated for denture wearers with dry mouth. Its unique hydrogel chemistry provides a maximum hold while the proven patented salivary enzyme system soothes minor irritations, protects against fungal build-up, and fights odor-causing bacteria. For more information, call (800) 922-5856 or go to www.biotene.com.

Alternative to Antibiotics May Be More Effective, Less Harmful

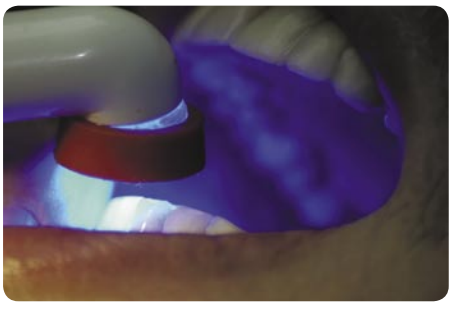
Photodynamic therapy may be an effective way to treat the bacteria associated with periodontal diseases, and could provide a better option than antibiotics or other mechanical methods for treating periodontal diseases, according to a new study published in the *Journal of Periodontology*.

Researchers at São Paulo State University found that using photodynamic therapy was an effective method to minimize destruction of periodontal tissue that can accompany treatment for periodontal diseases. In a rat population, photodynamic therapy did minimal damage to periodontal tissues, in comparison to other techniques including scaling and root planing, and antibiotic therapy.

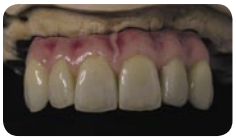
"We found that PDT is significantly less invasive than other treatments for periodontal diseases," said study author Dr. Valdir Gouveia Garcia, of the Department of Periodontology at São Paulo State University. "It can provide improved dentin hypersensitivity, reduced inflammation of the tissues surrounding the teeth, and allows tissues to repair faster."

Photodynamic therapy may be an alternative to antibiotic treatment, which is becoming increasingly important as antibiotic resistance increases. This form of therapy involves two stages: first, a light-sensitive drug is applied to the area. Second, a light or laser is shone on that area. When the light is combined with the drug, phototoxic reactions induce the destruction of bacterial cells.

"This is an exciting finding," said Preston D. Miller, Jr., DDS, and president of American Association of Periodontology. "PDT may be an effective therapy for the treatment of periodontal diseases. While patients have many options for treating their periodontal diseases, PDT could prove to be a preferable alternative to antibiotic therapy. Unfortunately, long term antibiotic therapy not only decreases the drug's effectiveness, but also may lead to the development of drug resistant organisms."



New Gingival Shades for Creation CC and Creation ZI →



Creation Willi Geller has expanded its ceramic range with high-quality gingival shades for metal-lo- and zircon ceramic. The Creation CC Gingiva Kit is available with paste and powder opaquer in six shades: purple, dark and light pink, flamingo, rose and dark pink opaque; and a neutral ceramic. Creation ZI Kit contains the same shades but an additional Frame Shade instead of the opaquer. For more information, go to www.creation-willigeller.com.

Surge in Arthritis Cases Predicted

By 2030, Americans with arthritis and other rheumatic diseases will surge by 46 percent (roughly 67 million people), or about 25 percent of the population, according to federal public health officials.

In a recent issue of the *Wall Street Journal*, popular retirement states - Arizona, Florida and Nevada - will feel the brunt more acutely. The Centers for Disease Control estimated that arthritis cases in Arizona will increase by 87 percent, or 1 million people.

While health officials noted medication can alleviate some pain and immobility problems associated with arthritis and other age-related degeneration of the joints, physical activities are a more long-term solution for those with arthritis and those at risk for the disease.

Dean Bertolami Heads to the Big Apple

Long known as a leader in the dental research, education, and clinical communities, Charles N. Bertolami, DDS, DMedSc, has been named the 14th dean of the New York University College of Dentistry. He will assume the post at NYU's 142-year-old College of Dentistry on Sept. 1. He currently is in his 12th year as dean of the University of California, San Francisco, School of Dentistry.

In addition to expanding the school's research capacity, Bertolami also has enhanced the school's clinical and teaching programs, including renovating clinics and laboratories; implementing a new curriculum reinforcing integration of basic and clinical sciences in dental education; establishing and expanding joint degree programs; and establishing a year-long postbaccalaureate program for students from economically or educationally disadvantaged groups. The UCSF School of Dentistry has also led the nation in overall NIH funding for dental schools.

John Sexton, NYU president, said, "Under Mike Alfano's deanship, the College of Dentistry went through a remarkable transformation: There was a renewed and powerful emphasis on research, the facilities were upgraded, the role of dentistry was expanded, new healthcare collaborations were envisioned, the quality of students improved greatly, and the College of Nursing became part of the Dental College. Finding a successor who could sustain that momentum was a significant challenge, but Charles Bertolami is ideally suited not only to sustain it, but accelerate it."

Robert Berne, NYU's senior vice president for Health, said, "If you go to a dentist in the United States, chances are 1-in-12 that you will be cared for by a graduate of the NYU College of Dentistry. We have an obligation, therefore, to ensure that the leader of the school is among the best in the country, a person who can set an agenda for excellence in research, education, and clinical care delivery and envision new possibilities for the role of the profession within the health care field."

USC-led Researchers Use Stem Cells to Regenerate Parts of Teeth

A multinational research team headed by University of Southern California School of Dentistry researcher Songtao Shi, DDS, PhD, has successfully regenerated tooth root and supporting periodontal ligaments to restore tooth function in an animal model. The breakthrough holds significant promise for clinical application in human patients. The study appeared in the inaugural issue of *PLoS ONE*.

Using stem cells harvested from the extracted wisdom teeth of 18- to 20-year olds, Shi and colleagues have created sufficient root and ligament structure to support a crown restoration in their animal model. The resulting tooth restoration closely resembled the original tooth in function and strength.

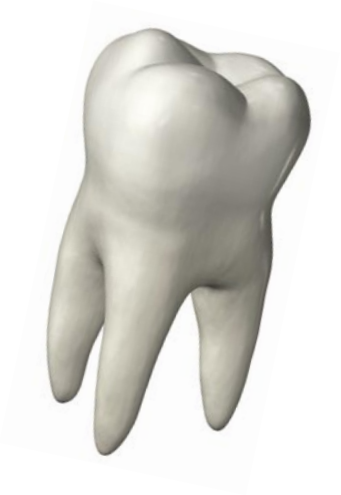
The technique relies on stem cells harvested from the root apical papilla, which is responsible for the development of a tooth's root and periodontal ligament. Previous studies, conducted by Shi and Stan Gronthos at the National Institutes of Health, had utilized dental pulp stem cells. Shi found the new technique to be superior.

"The apical papilla provides better stem cells for root structure regeneration. With this technique, the strength of the tooth restoration is not quite as strong as the original tooth, but we believe it is sufficient to withstand normal wear and tear," Shi said.

Shi hopes to move the technique to clinical trials within the next several years, a potential boon for dental patients who are not appropriate candidates for dental implant therapy, or would prefer living tissue derived from their own teeth.

"Implant patients must have sufficient bone in the jaw to support the implant. For those who don't, this therapy would be a great alternative," Shi said.

According to Shi, the not-so-distant future may be one in which not only wisdom teeth, but those baby teeth once left to the tooth fairy for a pittance, will become valuable therapeutic tools.



New glDEPod Personal Study Station: Flexible Dental Learning in Your Pocket

Global Institute for Dental Education has launched its newest education product, the glDEPod Personal Study Station. The station, complete with iPod and 7-inch LCD monitor comes loaded with 20 DVDs, video interviews with experts and select live patient surgical videos. The iPod contains more than 40 hours of education and sits neatly in its own customized slot within the monitor. It is lightweight and fits easily into a briefcase for carrying from home to office, to travel. For more information, go to www.globalinstituteonline.com.

TABLE 2

Patient History in Evaluation for Xerostomia

Medical History	Past and present medical diagnoses Past and present medical treatments Undiagnosed symptoms
Medication History	Name of medication Dosage/change in dosage Reason for taking How long taken
Dental History	Types of dental treatment Extent of dental treatment Oral home care practices Dietary habits
Patient Perception of Oral Condition	Do you have a sticky, dry feeling in your mouth? Do you have trouble chewing, swallowing, tasting, or speaking? Do you have trouble wearing a denture? Do you have a sore or burning feeling in your mouth? Do you have bad breath?

CORRECTION

An incorrect title appeared on a table in the June issue of the *Journal*. The corrected table appears at left. It is Table 2 for "Dental Management of Xerostomia — Opportunity, Expertise, Obligation" by Cynthia L. Kleinegger, DDS, MS.

CDA JOURNAL, VOL 35, Nº7

"Give yourself directions to stay on track."

BEN BERNSTEIN, PHD

DENTIST, CONTINUED FROM 465

"Stress is a function of disconnection in the body, mind, or spirit," he said.

For optimal performance, people need to be connected in all three areas. He outlined the qualities of being calm, confident, and focused, which reflect respective connections with the body, mind, and spirit.

Awareness of disconnection is crucial to keeping stress at bay and performance at a peak. To keep calm, confident, and focused, Bernstein shared the following tools to help reconnect:

TO STAY CALM:

- Breathe deeply down to your belly.
- Ground yourself. Feel the floor. Release tension.
- Sense your surroundings through your five senses. Bernstein had participants perform a simple exercise where they kept their head straight while turning their eyes to upper left and upper right, and then lower left and lower right. This practice engages peripheral vision and increases awareness.
- Try "the wedge." Bernstein introduced a practice referred to as the wedge, which activates all three techniques: Standing, take a moment to breathe out, visualizing breath reaching down the front of the body and all the way to the floor. Then breathe in, imagining your breath traveling up the back of the body to the head.
- Cultivate attributes that help maintain a calm demeanor including being: receptive, accepting, composed, grateful, patient, and harmonious.

TO STAY CONFIDENT:

- Confide in a trusted source and let go of negativity.
- Reflect back something accurate and positive.
- Envision taking small, manageable steps.
- Minimize negative self talk, which diminishes confidence.
- Keep your "personal radio" tuned to the positive. Bernstein encouraged listeners to be aware of thoughts such as I can't, I don't, I'm not." He asked all attendees think of their initials with the letter "K" in front — i.e., KAF, KPR, or KRT. "Think of your inner voice as your personal radio station, broadcasting all day, every day," he said. "Give yourself directions to stay on track."
- Cultivate attributes that help maintain confidence including being: fearless, effulgent, loyal, patient, resolved, and appreciative.

TO STAY FOCUSED:

- Stop and ask, "Is this distraction taking me to my goal?"
- Listen to your inner voice for the next step.
- Fulfill your purpose; see yourself taking action and getting back on track.
- Cultivate attributes that help maintain focus including being: determined, passionate, engaged, fulfilled, attentive and patient.

Bernstein's presentation at Spring Session was hosted by the CDA Well-Being Committee that offers support to members, families, and staff struggling with drug or alcohol addiction. During the lecture, he touched upon the consequences of too much stress including neglecting self-care and avoiding treatment that can spell trouble for dental professionals.

In closing, Bernstein reiterated the importance of positive connection through expressing appreciation for yourself and for others. "As professionals, you have the ability to educate, inspire, and empower patients to be healthy," he said. "You are making a sacred contribution to people's lives."

Honors

Grayson Marshall, DDS, professor and division head of Biomaterials, University of California, San Francisco, School of Dentistry has been given the 2007 Wilmer Souder Award for research in the field of dental biomaterials science by the International Association for Dental Research.

This year's Craniofacial Biology Research Award has been presented to **Karin Vargervik, DDS,** professor and interim chair, Division of Orthodontics, Department of Orofacial Services at the University of California, San Francisco. The award was part of the recent 85th General Session of the International Association for Dental Research.

CDA JOURNAL, VOL 35, Nº7

Selected Topics in Esthetic Case Management

EDMOND R. HEWLETT, DDS

GUEST EDITOR

Edmond R. Hewlett, DDS, is an associate professor, restorative dentistry, University of California, Los Angeles, School of Dentistry. He has maintained a private practice in restorative and prosthetic dentistry at the UCLA Faculty Group Dental Practice.

The importance of an attractive smile in contemporary culture — for better or worse — cannot be overstated, and has been extensively studied.[1,2] This social imperative for good looks and the pervasive marketing of dental products and procedures to consumers have combined to create an unprecedented demand for appearance-related dental treatment. Concurrent with this phenomenon is the inexorable progression of technology and the resultant array of diagnostic and treatment advances presently available to practitioners. Collectively, these factors have positively impacted dental practice busyness as more individuals seek elective treatments, and patients are benefiting from improved materials techniques. It's a good time to be a patient and to be a dentist.

Despite the advances, however, many fundamental principles of clinical dental practice remain unchanged. Specifically, prudent case selection, thorough diagnosis, and meticulous planning and execution of treatment — all with strict adherence to biologic and ethical principles — continue to define the standard of care. These principles must be applied to elective improvement of dental esthetics with the same diligence as that which traditionally guides the prevention and management of oral disease. The authors of this issue's articles have selected topics from the broad category of esthetic dentistry that cover some common clinical issues and reflect these principles of appropriate care.

Dr. Stephen R. Snow presents effective strategies for ensuring successful treatment outcomes in complex esthetic cases. This detailed article provides approaches to patient assessment, diagnosis, and esthetic treatment delivery employing evidence-based methods and current technologies.

Management of the periodontal-restorative interface is discussed by Drs. Paulo M. Camargo, Phillip R. Melnick, and Luciano M. Camargo. Their article focuses on crown lengthening in the esthetic zone, reviewing contemporary treatment modalities, and their indications.

Finally, my paper addresses the most common adverse event associated with the most popular esthetic dentistry treatment: tooth hypersensitivity induced by peroxide-containing whitening products. Current information on etiology and management are provided.

The authors hope you will enjoy this issue and find the information useful.

REFERENCES

1. Eli I, Bar-Tal Y, Kostovetski I, At first glance: Social meanings of dental appearance. *J Public Health Dent* 61:150-4, 2001.

2. Newton JT, Prabhu N, Robinson PG. The impact of dental appearance on the appraisal of personal characteristics. *Int J Prosthodont* 16:429-34, 2003.

CDA JOURNAL, VOL 35, Nº7

Strategies for Successful Esthetic Dental Treatment

STEPHEN R. SNOW, DDS

ABSTRACT The foundational principles of esthetic smiles reveal the direct influence of individual tooth alignment on dentofacial relationships. The use of clinical photography is an essential means to identify esthetic problems. Smile design provides an opportunity for effective communication to discuss treatment alternatives with the patient in the consultation process. The scope of treatment can be determined, and treatment limitations can be explained. Smile design findings influence preparation design, material selection, and laboratory communication for enhanced predictability and improved treatment success.

AUTHOR

Stephen R. Snow, DDS, is visiting faculty, University of California, Los Angeles, Center for Esthetic Dentistry; director, PERFECT Perspectives Advanced Dental Seminars, Danville, Calif., and in private practice emphasizing cosmetic restorative dentistry in Danville.

The prospect of performing cosmetic dental treatment is appealing. Recent media attention has heightened public awareness and increased demand for the services. Branding techniques that market specific products to patients rather than clinicians have enhanced patient inquiries for care as well. Since the services are often elective and directly requested by many patients, their willingness to accept treatment despite insurance coverage limitations may not be as restricted as with other treatment modalities.

Despite patient enthusiasm for optional procedures, however, the delivery of esthetic care presents many potential problems. There are many treatment alternatives available. Durability and performance of competing materials systems can be questionable. The appropriate scope of treatment may seem arbitrary. Selecting interdisciplinary strategies may be confusing as well.

The clinician needs an objective strategy to navigate through the patient examination and evaluation process. With objective consideration of the possible treatment alternatives that could be applied to meet the patient's goals, the proper treatment options can be presented and excellence in dental treatment can be delivered.

Esthetic Principles

Clinicians must be mindful of esthetic standards in evaluating how best to meet patient expectations. The more the elements of appearance deviate from known visual principles, the more likely patients will be disappointed with their smile. These principles are not dogmatic rules that must be applied and achieved for every patient.[1] Some patients are often disappointed with their appearance, however, they compare themselves to social and entertainment icons and perceive that they don't measure up. Although patients usually are focused on specific esthetic

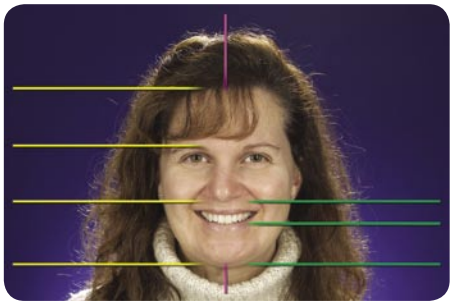


FIGURE 1. When viewed from a frontal perspective, the superimposed midline (magenta), upper/middle/lower thirds of the face (yellow), and lower third anatomical relationships (green) of this face are well-proportioned and conform to facial esthetic principles.

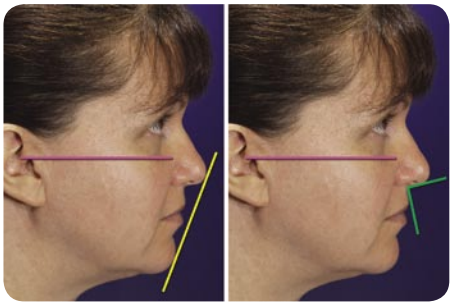


FIGURE 2. The Frankfurt horizontal (magenta) is parallel to the horizon in this sagittal perspective view. The maxillary lip is positioned approximately 4 mm posterior to the E-plane (yellow) while the nasolabial angle (green) is approximately 95 degrees.

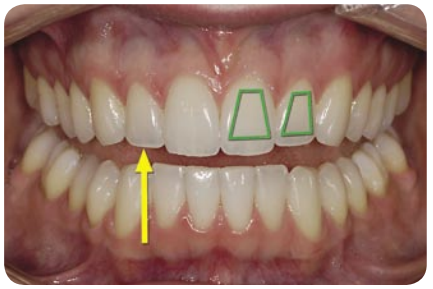


FIGURE 3. The proximofacial line angles combine with cervicofacial and incisofacial line angles to define the reflective "face" that accentuated the tapered appearance in this case. An increase in chroma from central incisor to canine is evident along with an anterior halo.

complaints, they are often unaware of the interrelation of multiple factors that combine to create the deficiencies they notice. It is prudent for clinicians to implement a disciplined approach in the diagnosis and subsequent delivery of dental care.

Esthetic principles can be categorized in three general groups: facial esthetic principles, dental esthetic principles, and dentofacial esthetic principles.[1]

FACIAL ESTHETIC PRINCIPLES comprise the overall skeletal relationships that affect the appearance of the middle and lower face. From the frontal perspective, the nasal, dental, and mental midlines ideally should coincide with the facial midline — a perpendicular line that bisects the interpupillary distance. The occlusal plane should be perpendicular to the midline and parallel to the horizon.[2,3] Attractive faces generally conform to the rule of thirds — with the upper, middle, and lower face segments each occupying approximately equal proportions of the vertical dimension of the face.[2,4,5] (**FIGURE 1**). Within the lower third of the face, the distance from the base of the nose to the incisal edge/lips should represent approximately one-third of the space, while the distance from the incisal edges/lips to the chin occupies the remaining two-thirds.[3] Attractive faces generally display an overall symmetry.[2,5] From a sagittal perspective, the nasolabial angle typically should fall in the range of 90 degrees to 95 degrees for males and 100 degrees to 105 degrees for females.[1,3,4] E-plane evaluation ideally reveals the maxillary lip is positioned 2 mm to 4 mm posterior to line from tip of nose to tip of chin.[1,3,4] (**FIGURE 2**).

DENTAL ESTHETIC PRINCIPLES comprise the nuances of contour and color characteristics of individual teeth. The contour of a tooth can be analyzed in three-dimensional views: from the facial, interproximal, and incisal. The "face" of a tooth has been defined as the reflective area inside the transitional line angles of the facial surface.[6] Although the silhouette of each tooth contributes to its appearance, the light reflection from the face of the tooth defines its apparent shape (**FIGURE 3**).

The inherent layers of tooth composition determine the characteristics of its color appearance. The internal dentin possesses the most chroma and opacity while the enamel is more translucent with significantly less chroma. These optical properties combine with the natural variations in thickness of each layer to produce a polychromatic shift within each tooth. Typically, there is also a polychromatic shift within the arch in which the canine teeth have a higher chroma and lower value than that of the central incisors[7] (**FIGURE 3**).

Additional color nuances are created by the subtle surface characteristics of teeth. A whitish surface haze may be present to form an enamel veil that partially obscures the visibility of the underlying tooth layers. Refraction caused by the incisal table of anterior teeth may scatter light to produce the appearance of a halo, a thin light line at their incisal edges (**FIGURE 3**). Finally, the appearance of tooth color is influenced by its surface topography.[6,8] The anatomy of developmental vertical undulations, the texture of lines and pits, and the relative glossy luster of a tooth alter the reflective qualities of its surface (**FIGURE 4**). The more light is reflected and scattered from the surface of a tooth, the less the underlying color is apparent.

DENTOFACIAL ESTHETIC PRINCIPLES are somewhat more complex in that they represent a blend of both facial structures and dental structures.[9] Theses principles are determined by tooth arrangement, the position of a tooth in space relative the others in the arch. These principles include the relative width and height of the teeth in the anterior segment.[1,6,11] The Golden Percentage of 1.618 : 1.0 can be converted and modified to the Golden Percentage for assessment of proportions and central incisor dominance as well as bilateral symmetry of maxillary anterior tooth width.[10]

When viewed from the frontal aspect, the width of each maxillary anterior tooth is measured mesiodistally at its maximum visible height of contour as viewed from the frontal aspect. The individual width of each tooth is divided

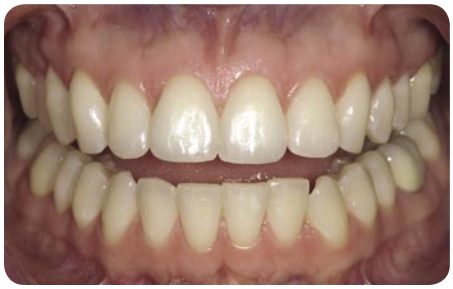


FIGURE 4. A combination of vertical developmental undulations, random surface irregularities and a satin quality luster all contribute to scattered light reflection that partially obscures the visibility of the underlying tooth color.

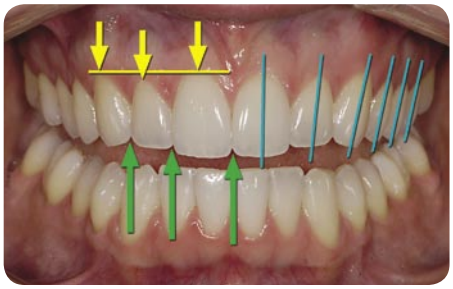


FIGURE 5. The mesial axial inclination (blue) increases from central incisor to canine and then remains constant in the posterior segment. The apical migration of the interproximal contacts with each successive distal contact matches the associated incisal embrasure (green). The "high-low-high" gingival zenith pattern is ideal in this case.

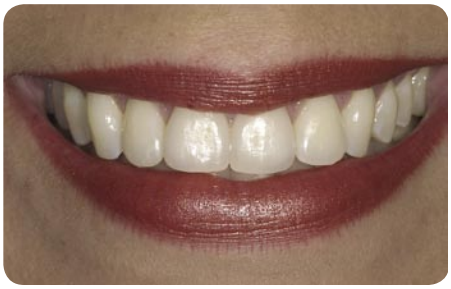


FIGURE 6. The smile line generally follows the curvature of the mandibular lip, and the esthetic zone is appropriately filled with "white space." The overall visual impact of the arrangement is pleasing from social distances despite obvious asymmetry in lateral incisor rotation.

by the sum total to reveal the percentage that each tooth contributes to the total canine-canine width. As an initial reference, the width percentage of the maxillary central incisors, lateral incisors, and canines should approach 22 percent; 16 percent; and 12 percent, respectively.[11] The width-height ratio of a maxillary central incisor should approximate 75 percent.[1,2,5] While these ratios produce pleasing anterior proportions representing the "media look" that patients may visualize and desire for their own smiles, minor variations are appropriate to blend with differing arch form and tooth arrangement appearance that accompany different facial shapes (i.e., longer versus shorter, wider versus narrower).[1,5,11,12]

A line extending from the height of the emergence of the tooth from the free gingival margin to the center of the incisal edge or incisal cusp tip implies the alignment of the axis of each tooth as its root extends into the alveolus. The maxillary anterior teeth ideally display mesial axial inclination gradation, with the central incisors appearing to be the most vertical and the lateral incisors and canines each tipping more toward the midline[5,6] (**FIGURE 5**). Beyond the canines, the remaining posterior teeth should display an inclination that is parallel to the canines.[5]

In an analysis of the normal position of interproximal contacts from mesial to distal within an arch, there is an apical migration. The occlusocervical position of interproximal contacts on an individual tooth reveals the distal contact is usually positioned further toward the apical than the mesial contact. As a result, the incisal embrasure form in the anterior also exhibits a gradation — increasing in depth from central incisor through canine (**FIGURE 5**). While minor differences are desirable, pleasing smiles exhibit a high degree of radiating symmetry.[2,5,6]

Dentofacial principles include evaluation of the collective appearance of the teeth in relation to the lips. Generally, the smile line should create a gentle, convex curve that follows the lower lip[1-3,6,12] (**FIGURE 6**). The oral structure revealed in a full smile should maximize white space (teeth) while appropriately minimizing black space (diastemas, excess buccal corridor space) and pink space (gingival display).[6] When the lips are retracted, the gingival frame components of the smile can be evaluated. Ideally, the emergence of the maxillary anterior segment should form a symmetrical "high-low-high" pattern in which the free gingival margin of the canine and central incisor are at the same height and the free gingival margin of the lateral incisor is positioned just incisal to that[1,5,6,9] (**FIGURE 5**). The gingival zenith represents the most apical point at which each tooth emerges from the free gingival margin. For an esthetically pleasing smile, it should be positioned distally to the center of each tooth within the maxillary anterior segment. The distal position gradually increases from the central incisor to the canine.

While each of these dentofacial principles can be evaluated independently, they are all affected by four specific tooth arrangement factors that affect the appearance of a smile:

- Arch form,[10,11]
- Buccolingual position of each tooth,
- Mesiodistal position of each tooth, and
- Rotation of each tooth.

If a smile presents a smooth evenly curved arch form free of buccolingual displacement, mesiodistal displacement, and rotation, the ideal dentofacial relationships are often present as well, creating a pleasing appearance.[11] A tooth arrangement with a collapsed palatal vault, buccoverted teeth, linguoverted teeth, overlapped teeth, diastemas, or rotated teeth often exhibits many violations of dentofacial principles and is unesthetic.

Documentation and Communication

While patients are often aware of esthetic problems they want resolved, they are often unaware of the interrelation of tooth arrangement factors in smile design. Even though there may be several elements simultaneously contributing to make a smile unattractive, it is only after the chief complaint is resolved that the next most egregious esthetic violation may become apparent to the patient. The cosmetic dentist

FIGURE 7. Wand-type intraoral cameras offer convenience for digitally capturing freeze frame images or video sequences. The small size of the wand unfortunately mandates the need for a small internal sensor with low resolution. The images may appear pixelated and distorted.

FIGURE 8. Digital single lens reflex camera systems allow use of macro (close-up) lenses with manual focus for repeatable diagnostic magnification. The large camera body can accommodate a large sensor offering high resolution and superior color accuracy.

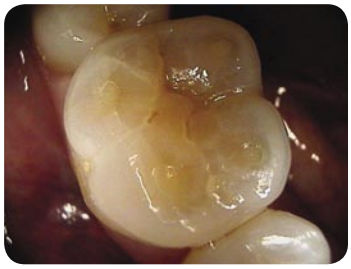


FIGURE 9. This image was captured with a wand-design intraoral camera. The pixel dimensions of the image were 640 x 480. Note the uneven lighting, grainy/pixelated appearance, and wide angle distortion.

should possess a wealth of knowledge and experience in order to make appropriate treatment recommendations to address these concerns. Clearly, this perspective is not shared initially by the patient. The clinician must have a means to introduce smile design principles to patients for their consideration prior to treatment.

Routinely, dentists perform comprehensive evaluations for patients as they begin care in the office. Comprehensive clinical examination includes reviewing the medical history, assessment of temporomandibular joint and musculoskeletal function, evaluation of occlusal function and harmony, assessment of surrounding soft tissues, examination of periodontal tissues, and an evaluation of each tooth, both clinically and radiographically.

Beyond objective written documentation regarding the presence or absence of positive findings in these categories, the dentist must also consider methods for the documentation of the subjective esthetic elements of the smile. There is no question that photography presents the most effective way to record pretreatment conditions and post-treatment results. Accurate clinical photography has become an integral part of the standard of care for appropriate documentation of the teeth and surrounding structures.

There are currently two prevalent modalities used for clinical photography in the dental office: fiber optic "wand" camera systems, and digital single-lens reflex camera systems (**FIGURES 7-8**). Both systems record light with a solid-state sensor through an electrical reaction. A charge-coupled device, CCD, or a complimentary metal oxide semiconductor, CMOS, photodiode detector stores an electric charge that corresponds to the amount of light that strikes each portion of the sensor. Initially the electrical energy is converted into individual dots of digital color information that are combined to create the final image. Each dot of color data represents the basic visible unit of the detail of the digital image. Each picture element is called a "pixel."[13] The greater the number of pixels captured by CCD or CMOS sensor, the better the quality of the recorded image detail.[13,14]

The first wand system was the Fuji Dentacam introduced in 1986. Since that time, several manufacturers have entered the marketplace with similar products, but the units have become more compact and affordable. The wand design mimics an intraoral dental mirror to facilitate a visual "tour" of the mouth with the potential for freeze frame as well as video capture. Input and subsequent image review are directly stored to and retrieved from a local computer hard drive with proprietary software. While these systems are essentially "plug-n-play," the resolution and quality of the resulting images is mediocre at best (**FIGURE 9**).

Digital camera systems provide the alternative method for intraoral photography. Although there are a many digital cameras on the market for general photography that all allow rapid visualization of captured images, repeatable diagnostic dental photography requires a digital single-lens reflex camera system that allows interchangeable lens selection.[14] Macro lenses with a fixed focal length designation of 100 mm to 105 mm provide the ideal combination of magnification ability and working distance convenience for dental purposes.[15] The resolution and color accuracy are far superior to that of wand-type systems (**FIGURE 10**). Manual focus capability is required to create images with useful magnification ratios ranging from 1:1 (for close-up views) to 1:10 (for full-face images).

The camera body coordinates the functions of the image capture by regulating the amount of light that is allowed to expose the digital sensor with the exposure time (shutter speed) and lens opening diameter (aperture).[15] In addition to affecting the amount of light that enters the camera, the aperture also affects the amount of the scene that appears to be in focus. When a small diameter aperture is used, a larger portion of the scene in front and behind the actual focal point appear to be in focus as well.[13] Camera systems that are capable of manual aperture settings to maximize the zone of focus are ideal for dental documentation purposes. Supplemental light is supplied by a dual-point strobe flash is best for intraoral

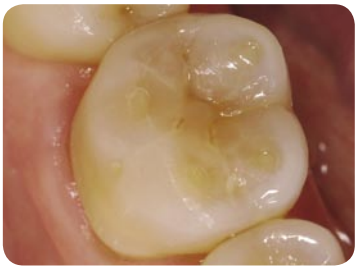


FIGURE 10. This same tooth, as in Figure 9, but the image was captured with a DSLR. The pixel dimensions of the 2592 x 1885 after cropping to match the perspective of Figure 9. Note the even illumination, lack of pixelation, and improved color representation.

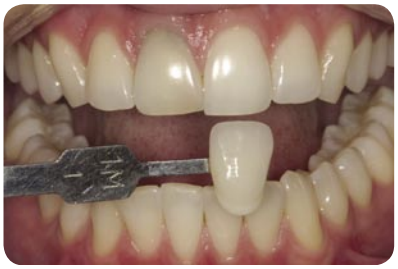


FIGURE 11. Laboratory shade images should have a shade tab in the same plane as the documented tooth. Beyond hue and chroma, photographs are the most effective means to communicate nuances in translucency, texture, incisal effects, and contour.

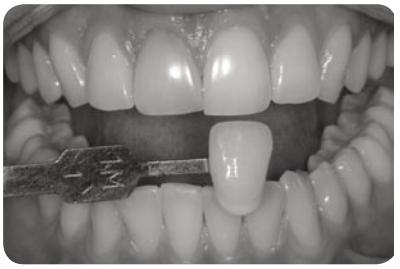


FIGURE 12. Black and white (gray scale) images aid in evaluation of value without the unwanted misinterpretations that can be caused by adjacent colors. Some DSLRs are capable of b/w capture, but color pictures can also be converted to gray scale with computer software.

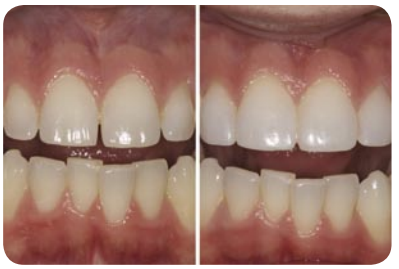


FIGURE 13. Maxillary anterior dentition with mild diastemas prior to treatment (a) and with diastema closure after conservative direct resin restorations (b). Tooth proportions were improved simultaneously with the alteration in tooth contour.

purposes. A twin-flash design may offer the best combination of soft, uniform illumination while simultaneously revealing surface detail, color transitions, translucency variations, and crack lines.[15]

The applications for digital intraoral photography have greatly enhanced the documentation of clinical evaluation. Photographic images are indispensable for the documentation of pretreatment conditions, clinical treatment steps, and post-treatment results. Patients are often motivated to enroll in dental treatment through co-diagnosis with preoperative digital images.[16,17] Clinicians can utilize photographs of treatment performed for other patients to provide an example of specific procedures and the results they can achieve.[18,19] Photographic images augment both oral and written clarification in presenting informed consent prior to commencing treatment.[17,18,20,21] Additionally, visualization of potential treatment results can stimulate patient involvement that develops the relationship between the clinician and patient.[22,23]

During delivery of esthetic dental treatment, color photographs are indispensable in communicating shade nuances to laboratory technicians.[24,25] The images communicate the color of surrounding dentition as well as underlying preparations. Proportions and positions of enamel tints, characterization intensities, degree of translucency, depth of opacity, and incisal edge can be adequately captured (**FIGURE 11**). Black and white photographic images can provide a visual description of surface texture, as well as an objective measure of tooth value (reflectivity)[26] (**FIGURE 12**).

Since laboratory technicians fabricate restorations with stone models, photographic images of provisional restorations are imperative to visualize dental proportions in relationship to surrounding soft tissues.[27] Photographs enable technicians to evaluate smile line harmony, horizontal occlusal plane orientation, and white/black/pink space proportions revealed in a full smile. Photographs of lips in repose show the incisal edge display at rest.[28,29] Photographic images of postoperative results can provide feedback for self-assessment to each member of the restorative team for the opportunity to learn and improve future results.[30] Digital images of pre-existing clinical conditions can validate and verify the need for treatment delivery when submitting insurance claims.[19]

Restorative Alternative Perspectives

The clinician must deliver care that satisfies the patient subjectively and the clinician objectively. To be successful, the treatment must meet or exceed patient expectations. As a dentist considers the wide array of possible esthetic treatment recommendations for their patients, the choices can seem daunting. Just because a treatment modality is possible, it may not be predictable — or even advisable. The best dental treatment recommendations and subsequent dental care delivery decisions are evidence-based, relying on sound clinical research to formulate treatment protocol.[31]

Advances in adhesive dental technology have allowed clinicians to consider and deliver esthetic treatment modalities that were previously not possible. Direct resin restorations provide a plethora of predictable treatment possibilities for minor alterations in tooth contour or color with minimal preparation.[32,33] (**FIGURE 13**). Stacked powder-liquid ceramics offer additional improvement in surface durability and color stability through indirect fabrication. Since these conservative restorations can be fabricated with thin labiolingual dimensions, they require minimal tooth reduction and afford maximum enamel preservation. By bonding directly to enamel, the adhesive interface is durable, predictable, and maximized.[34,35] Delivery of these cosmetic services requires sig-

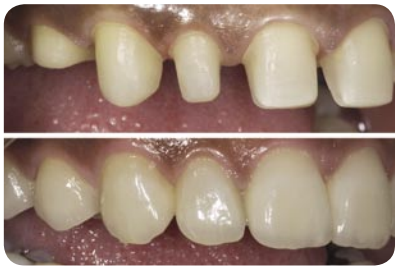


FIGURE 14. Maxillary dentition undergoing treatment for large diastema closure with preparations designed to maximize enamel retention and enamel margins (a) and after cementation of pressed ceramic restorations (b).

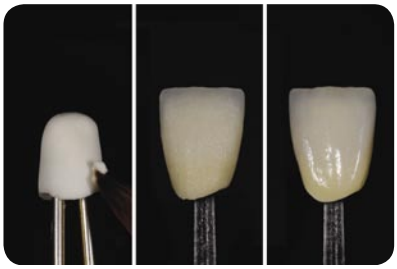


FIGURE 15. Laboratory fabrication of a zirconia-core crown. Fluorescent masking layer to applied to the white zirconia coping (a) is undetectable within the body build-up with porcelain margin, dentin layers and incisal window (b), or the completed crown (c).

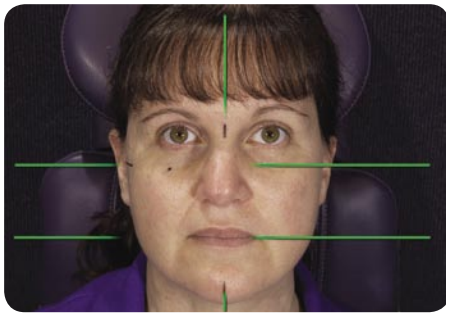


FIGURE 16. The Frankfurt horizontal and interpupillary midline are recognizable landmarks that can be utilized to create an alignment grid to capture images with repeatable, diagnostic angulation.

nificant skill. Ceramic construction with liquid-powder systems requires the use of refractory dies or twin foil techniques. Considerable experience is required of the laboratory technician.[36] Furthermore, clinical circumstances don't always meet the ideal criteria required for placement of conservative esthetic restorations. Broken teeth, missing enamel, and parafunctional habits all present challenges that render the long-term outlook for conservative cosmetic restorations questionable.[37-42]

Ceramo-metal restorations were previously the only viable restorative option if additional strength was needed for clinical durability by virtue of the support of their metallic inner core. While the restorations have proven to be predictable, they have two significant liabilities.[43] The metallic core is both dark and opaque. The esthetic consequences are problematic. The core casts a shadow that prevents light transmission into the root.[44,45] The overlying gingiva can appear objectionably dark. The color of the core material has to be optically masked. The preparation dimensions must necessarily be deep to allow room for masking techniques and materials. Even with an aggressive preparation design and subgingival margin placement, significant technical skill is required to mask the core without creating an opaque appearance that is readily detectable.[46] Since ceramo-metal restorations were traditionally cemented, a circumferential preparation was mandatory, and retention was determined by the length and parallelism of the opposing axial walls.[47]

Pressed ceramic systems were developed as an esthetic restorative alternative to overcome some of these obstacles. Pressed ceramic restorations provide enhanced cohesive strength to expand the amount of unsupported restorative material that can augment the contours of teeth without the need for a metal core.[48-50] This restorative strategy presents many advantages. By eliminating the internal metal coping, excessive opacity is reduced, and improved optical properties are more readily achieved.[51] The ability to etch the ceramic interface allows adhesion for restoration retention. Preparation design can be more conservative, and partial coverage restorations are possible (**FIGURE 14**). Translucent luting cements allow the placement of supragingival margins. Pressed ceramic fabrication techniques allow the dental laboratory to create ceramic margins with procedures that mimic the lost-wax techniques utilized in cast gold restorations.[52] With familiar fabrication strategies and desirable optical properties, the esthetic treatment modalities could be offered by a wider spectrum of dentists being supported by a larger number of technicians.[53,54]

Unfortunately, the pressed ceramic fabrication process came with limitations of its own. Although more conservative than that required for ceramo-metal restorations, minimum preparation depths were still required by material manufacturers to meet the physical constraints of the material itself.[55] These criteria often result in the complete removal of tooth enamel in all prepared areas.[56,57] Research has shown that tooth flexure increases significantly with the percentage of tooth structure removed.[58,59] Since the ultimate strength of a pressed restoration is directly dependent on the strength of the underlying tooth structure, increased tooth flexure can result in increased ceramic fracture. If pressed ceramics are utilized to create the illusion of improved tooth alignment, the resulting combination of tooth reduction, tooth flexure and occlusal forces may create a combination that could result in restoration failure.[60-62]

More recently, alternative ceramic materials have been developed to replace the metal in strengthened-core porcelain restorative strategies. Alumina and zirconia-based materials provide a densely sintered crystalline structure with physical properties that rival metal-based systems.[63-65] Even though preparation depth requirements are the similar to ceramo-metal restorations, the white ceramic core is somewhat easier to mask.[66,67] (**FIGURE 15**). Laboratory fabrication of the ceramic copings can be outsourced to centralized locations and then returned to the initial lab for completion of contour and shade matching with standard veneering techniques that mimic those used for ceramo-metal fabrication. Through the development of ceramic systems that utilize familiar fabrication strategies and with improved

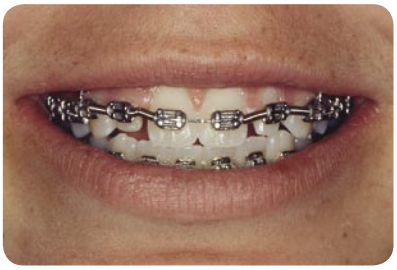


FIGURE 17. A pretreatment photograph of the full smile of a patient at the initial evaluation appointment utilizing the Frankfurt horizontal and interpupillary midline as alignment grid landmarks.

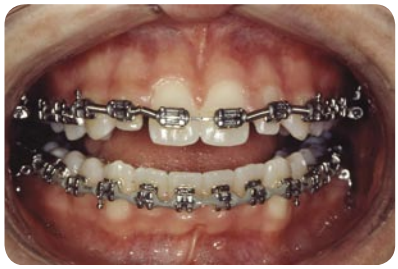


FIGURE 18. A pretreatment photograph of a frontal retracted view of the same dentition as Figure 17 utilizing the same alignment guides. Nearly identical alignment allows both images to be superimposed for smile design purposes.

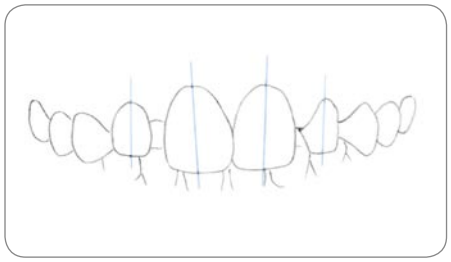


FIGURE 19. The initial tracing of the pretreatment tooth arrangement of Figure 18. A retracted view allows accurate duplication of the gingival frame. Blue lines were added to aid visualization of the existing axial inclination of the incisors.

optical properties, strengthened esthetic treatment modalities can again be offered by a broader range of dentists with supported by a larger number of technicians.

In planning for cosmetic restorative treatment, the clinician must balance the specific needs of the patient with the advantages and disadvantages of each available treatment modality. The clinician must have a method of comparing the pretreatment findings with the desired outcome to choose the alternative on behalf of the patient.

Smile Design

Specific treatment modalities can only be considered after a comprehensive evaluation of facial and dental structures is performed and the desired outcome is previsualized.[3] Assessment for developing esthetic treatment plans begins with excellent intraoral photographic documentation.[14] Different images are required to evaluate the full spectrum of esthetic principles for each patient. A view that captures the entire head of a patient would be required to evaluate facial balance principles (e.g., interpupillary line, midline, occlusal plane, E-plane, nasolabial angle). A view with the lips in repose is useful to assess the incisal edge display at rest. A view with a full smile is required to evaluate dentofacial principles involving the degree of harmony of the lips with the underlying dental structures (e.g., convex smile line, gingival display, buccal corridors). Finally, a retracted view with lips pulled out of the way is needed to assess gingival frame principles and individual tooth characterization (e.g., gingival emergence pattern, maxillary tooth proportions, axial inclination gradation, polychromatic tooth gradation).

By utilizing repeatable facial landmarks as a guide for camera alignment, multiple images can be captured with identical alignment in photography, even if they are taken for different purposes (i.e., full smile versus retracted) or on different days (i.e., pretreatment versus post-treatment). It has been suggested that the Frankfurt horizontal and the interpupillary midline are examples of convenient, unchanging landmarks that can be utilized for consistency in dental photography[68] (**FIGURE 16**). Tracings of images with identical alignment can be superimposed to allow the simultaneous evaluation of all esthetic principles, with or without the lips in place (**FIGURES 17-18**).

The initial tracing of the maxillary teeth, as seen in a retracted view, provides the basis for evaluating the position of teeth at the time of the examination (**FIGURE 19**). A second piece of tracing paper is placed over the first for the development of a smile design framework that incorporates the aforementioned esthetic principles. Vertical lines representing frontal height of contour of the maxillary canines are drawn to define the maxillary canine-canine width. The distance is divided in half and marked with a third vertical line representing the proposed dental midline. The remainder of the maxillary anterior segment is divided with vertical lines that correspond to 22 percent, 16 percent, and 12 percent of the total canine-canine width. These width relationships reflect the ideal proportions of a modified Golden Percentage analysis.

The width of the central incisor is divided by 0.75 to determine the height needed for a width:height ratio of 75 percent. The calculated height for the central incisor is used to position a gingival guideline in harmony with the upper lip reveal and a smile line in harmony with the curvature of the lower lip. The gingival framework may be drawn as a straight horizontal line, only if the initial photograph capture was aligned with the Frankfurt horizontal landmarks. Mesial axial inclination guidelines and embrasure depth guides are added in contrasting colors to complete the framework (**FIGURE 20**).

Another piece of tracing paper is superimposed over the outline of the existing teeth and the ideal smile framework. Each tooth of the anterior segment is added in its position within the designed tooth arrangement. By conforming to the boundaries and guidelines of the framework dimensions, the proposed smile design will simultaneously possess all of the desired dentofacial principles. The clinician can then compare the difference between the underlying tracing of the existing tooth arrangement with the proposed tooth arrangement of the superimposed smile design (**FIGURE 21**).

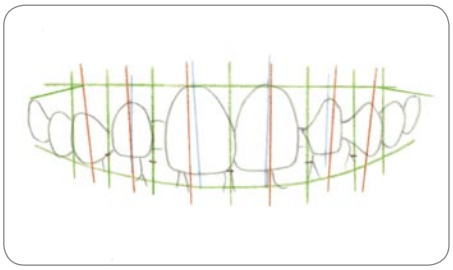


FIGURE 20. A design framework is superimposed over the original tracing. It represents guidelines for anterior tooth proportions, angulations, embrasures, and gingival emergence as dictated by the canine-canine width and lip reveal of the individual patient.

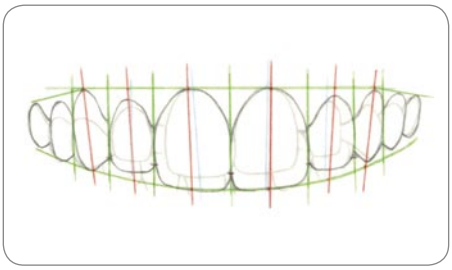


FIGURE 21. A proposed smile design is developed and superimposed to conform to the dentofacial principles of the completed framework. Disparities suggest treatment alternatives (e.g., additional orthodontics, posterior segment crown lengthening, anterior veneers).

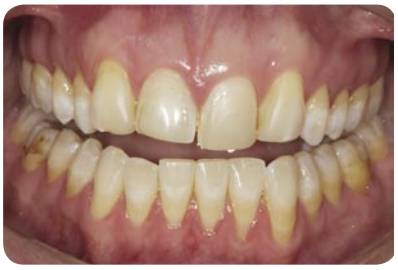


FIGURE 22. A pretreatment retracted view reveals arrangement deficiencies (including missing lateral incisors) that contribute to a canted smile line, inappropriate anterior proportions, embrasure irregularities, and gingival pattern violations.

Application and Implementation

Some esthetic dental problems are related to dental principle violations in color or contour. Tooth wear, for example, could detract from the proper appearance of tooth form while excessive intrinsic chroma might adversely affect the polychromatic shade shift within a tooth. Often dental principle issues can be addressed with conservative treatment options. Occasionally, tooth characterization difficulties can be addressed on a limited or even isolated basis.

Dentofacial principles violations, however, are more complex since tooth arrangement factors are always the cause and since improvement in tooth alignment is the logical treatment of choice (**FIGURE 22**). Orthodontic treatment is often the only treatment alternative that ultimately can produce an ideal result in dentofacial relationships.[70] With the advent of elective esthetic treatment, however, patient expectations regarding treatment options can be misunderstood or even unrealistic. Patients may look to restorative treatment modalities to avoid the traditional alternatives that would predictably achieve the results they desire.[69] While patients may prefer to explore restorative alternatives with accompanying periodontal crown lengthening surgery, continued smile principle violations (e.g., in width proportions, embrasure gradation, gingival emergence pattern and symmetry) are inevitable if the underlying root positions remain unchanged (**FIGURE 23**). The dental team must have a method to help the patient consider the array of available treatment alternatives.

Beyond the use of photographic images alone, the creation of a smile design offers many powerful and effective communication opportunities for the dental team during the treatment consultation process. As the clinician draws the design, the patient directly observes the artistic ability and expertise of the dentist. This may prove beneficial in enhancing patient confidence or in helping a patient choose from among several possible offices for receiving esthetic care. Beyond merely boosting credibility for the dental team, however, the patient can easily visualize the disparity between the existing tooth arrangement and that of a design that conforms to accepted esthetic principles. The smile design allows the dentist to correlate objective clinical findings with the patient's stated priorities. At issue is the eventual determination of a treatment plan that will meet the patient's subjective expectations.

The doctor and patient can now collaborate as they assess the feasibility of achieving the proposed goals. With the help of the smile design, they can consider the esthetic problems caused by the dentofacial relationships (**FIGURE 24**). Periodontal procedures and orthodontic treatment should be considered as important supplements or even replacements to restorative care alone. An interdisciplinary approach is often required to achieve all the patient's expectations.[70] The more comprehensive the treatment plan, the more inclusive the application and achievement of esthetic principles in the delivery of care for complex cases (**FIGURE 25**).

If the patient chooses to limit treatment, however, it is essential for the clinician to present the predictable limitations in the results. If a patient with dental malalignment prefers restorative treatment alone to achieve the illusion of proper alignment, compromises in color, contour, emergence, and symmetry may remain unresolved as lingering esthetic liabilities. Additionally, patients may impair expected treatment results by insisting on the utilization of specific restorative materials. Many patients demand metal-free restorative solutions, and clinicians may be tempted to encourage their exclusive use.[71] The marketing tactics of some restorative material manufacturers may inappropriately persuade dental consumers to believe that one specific material or fabrication technique is applicable and preferable for all clinical circumstances. Unfortunately, patients may still hold the clinician responsible for any restorative failures in spite of the constraints that they imposed during treatment planning. Realizing what cannot be accomplished with a specific treatment option is just as important as understanding what can be achieved.

The smile design process represents

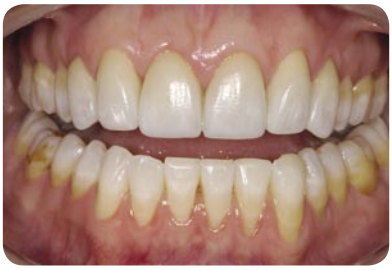


FIGURE 23. A post-treatment view of the same patient as Figure 22. Although restoration contours created the illusion of many esthetic improvements, the patient's refusal of comprehensive orthodontic and periodontal treatment resulted in persistent esthetic violations.

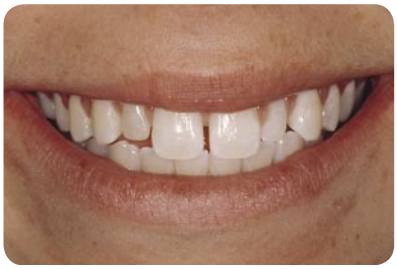


FIGURE 24. A preprosthetic view of the same patient as Figures 17-21. The patient agreed to additional orthodontics and posterior crown lengthening to position the teeth and gingiva appropriately to develop ideal anterior principles of proportion and alignment.

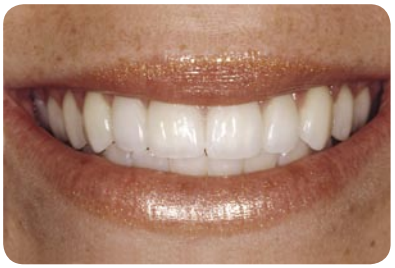


FIGURE 25. A post-treatment view of the completed case for the patient in Figures 17-21 and 24.

a tool to overcome these obstacles. In addition to objectively identifying the number of teeth that present esthetic distraction, it can indicate appropriate preparation design strategies that in turn require specific material selection recommendations. If tooth alignment is already ideal, facial surface preparation alone with maximum enamel retention may suffice. In that circumstance, direct resin restorations or powder-liquid ceramic veneers allow the most conservative treatment solution. If anterior width proportions are to be altered, additional interproximal preparation will be required, and significantly more enamel will be removed. In the case of traumatic fractures, significant enamel may already be missing. In the face of these increased restorative demands, pressed ceramic systems should be considered as a strengthened partial coverage alternative.

Although pressed ceramics allow partial coverage preparation design, occlusal function, and resulting flexural forces must be respected. Parafunction, abfraction, sclerotic dentin are all complicating factors. To establish anterior guidance, increase strength, and enhance predictability, full coverage preparations and ceramic modalities with internal strengthened cores may be indicated. Rather than inappropriately selecting a restorative material and then attempting to apply it to a patient's needs, the clinician can use the smile design to appropriately assess the patient's needs first and then select the restorative material that specifically meets those needs.[3] With a treatment planning paradigm driven by design, a dentist aptly may recommend and prescribe different restorative materials on a tooth-by-tooth basis. The dentist must then select a laboratory with the capability and experience to effectively utilize the required material systems.

Precise dimensional changes for periodontal, orthodontic, and laboratory procedures can be quantified, illustrated, and transferred to models, guides, and restorations. The prospect for predictable, coordinated treatment result is thus increased.

Conclusion

The contemporary photographic process is revolutionizing the way clinicians diagnose, treat, and communicate with patients and colleagues. Smile design techniques expand the use of photography to analyze existing esthetic problems and communicate possible treatment alternatives. Treatment acceptance occurs when patients perceive the recommended treatment will resolve current and future concerns for a fee that is commensurate with the benefits they gain. Patient satisfaction is achieved when the clinician meets or exceeds the patient's expectations. It is only through a balance in objective diagnosis, effective communication, and evidence-based planning that proper recommendations can be made for the delivery of excellence in cosmetic dental treatment. ■■■■

REFERENCES

1. Ahmad I, Geometric considerations in anterior dental esthetics: Restorative principles. *Pract Periodont Aesthet Dent* 10(7):813-22, 1998.
2. Chiche GJ, Pinault A, Esthetics of anterior fixed prosthodontics. Chicago, Quintessence Publishing Co., pp 13-73, 1994.
3. McLaren EA, Rifkin R, Macroesthetics: Facial and dentofacial analysis. *J Calif Dent Assoc* 30(11):839-46, 2002.
4. Arnett GW, Bergman RT, Facial keys to orthodontic diagnosis and treatment planning part II. *Am J Ortho Dent Facial Orthop* 103(5):395-411, May 1993.
5. Rufenacht CR, Fundamentals of Esthetics. Chicago, Quintessence Publishing Co., 33-66, 1990.
6. Rufenacht CR, Fundamentals of Esthetics. Chicago, Quintessence Publishing Co., 67-134, 1990.
7. Goodkind RJ, Schwabacher WB, Use of fiber optic colorimeter for in vivo measurements of 2,830 anterior teeth. *J Prosthetic Dent* 58:535-42, 1987.
8. Ubassy G, Shape and color, Chicago, Quintessence Publishing Co., 197-210, 1993.
9. Ubassy G, Shape and color, Chicago, Quintessence Publishing Co., 25-30, 1993.
10. Snow SR, Esthetic smile analysis of maxillary anterior tooth width: The golden percentage. *J Esthet Dent* 11(4):177-84, 1999.
11. Snow SR, Application of the golden percentage in smile design and esthetic treatment success. *Contemp Esth* 10(9):30-7, September 2006.
12. Morley J, Eubank J, Macroesthetic elements of smile design *J Amer Dent Assoc* 132(1):39-45, January 2001.
13. Bengel W, Mastering Digital Dental Photography, 2nd ed., Quintessence International Co., United Kingdom, 75-88, 2006.
14. Snow SR, Dental photography systems: Required features for equipment selection. *Compend* 26(5):309-21, 2005.
15. McLaren EA, Terry DA, Photography in dentistry. *J Calif Dent Assoc* 29(10):735-42, 2001.
16. Goldstein MB, Young R, Bergmann R, Digital photography. *Compend* 24(4):260-73, 2003.
17. Goldstein MB, Digital photography in your dental practice: The why's, how's, and wherefore's. *Dent Today* 22(4):98-101, April 2003.
18. Christensen GJ, Important clinical uses for digital photography. *J Am Dent Assoc* 136(1):77-9, 2005.
19. Wander P, Gordon P, Specific applications of dental photography. *Br Dent J* 162(10):393-403, 1987.
20. Christensen GJ, Informing patients about treatment alternatives. *J Am Dent Assoc* 130(5):730-2, 1999.
21. Christensen GJ, Elective versus mandatory dentistry. *J Am Dent Assoc* 131(10):1496-8, 2000.

22. Terry DA, Moreno C, et al, The importance of laboratory communication in modern dental practice: Stone model without faces. *Pract Periodontics Aesthet Dent* 11(9):1125-32, 1999.
23. Touati B, Miara P, Nathanson D, Esthetic dentistry ceramic restorations, London, UK, Martin Dunitz, 124-30, 1999.
24. Elter A, Canikliogl B, et al, The reliability of digital cameras for color selection. *Int J Prosthodont* 18(5):438-40, September-October 2005.
25. Dunn J, Hutson B, Levato C, Photographic imaging for esthetic restorative dentistry. *Compend* 20(8):766-78, 1999.
26. Zyman P, Etienne JM, Recording and communicating shade with digital photography: Concepts and considerations. *Pract Proced Aesthet Dent* 14(1):49-57, 2002.
27. Spear FM, Photography as a laboratory-communication tool. *Dent Econ* 84(5):90-1, May 1994.
28. Small BW, Location of incisal edge position for esthetic restorative dentistry. *Gen Dent* 48(4):396-7, July-August 2000.
29. Spear FM, The maxillary central incisal edge: A key to esthetic and functional treatment planning. *Compend Contin Educ Dent* 20(6):512-6, June 1999.
30. Clark JR, Digital photography. *J Esthet Restor Dent* 16(3):147-8, 2004.
31. Robbins JW, Evidence-based dentistry: What is it and what does it have to do with practice? Anecdote versus data — a case for evidence-based decision-making. *Quintessence Int* 29(12):796-9, 1998.
32. Magne P, Composite resins and bonded porcelain: The postamalgam era? *J Calif Dent Assoc* 34(2):135-47, February 2006.
33. Murchison DF, Roeters J, et al, Chapter 9: Direct anterior restorations, in Summitt JB, Robbins JW, et al, Fundamentals of Operative Dentistry — A Contemporary Approach, 3rd ed. Chicago, Quintessence Publishing Co., Inc., 2006.
34. Simonsen RJ, Calamia JR, Tensile strength of etched porcelain. *J Dent Research* 62:297, 1983.
35. Lopes GC, Thys DG, et al, Enamel acid etching: A review. *Compen Cont Ed Dent* 28(1):18-25, 2007.
36. Warden D, The dentist-laboratory relationship: A system for success. *J Am Coll Dent* 69(1):12-4, 2002.
37. Lehner CR, Mannchen R, et al, Variable reduced metal support for collarless metal ceramic crowns: A new model for strength evaluation. *Int J Prosthodont* 8(4):337-45, 1995.
38. Magne P, Magne M, Treatment of extended anterior crown fractures using Type IIIA bonded porcelain restorations. *J Calif Dent Assoc* 33(5):387-96, May 2005.
39. Troedson M, Derand T, Effect of margin design, cement polymerization, and angle of loading on stress in porcelain veneers. *J Prosthet Dent* 82(5):518-24, 1999.
40. Peumans M, De Munck J, et al, A prospective 10-year clinical trial of porcelain veneers. *J Adhes Dent* 6(1):65-76, 2004.
41. Donovan TE, Longevity of the tooth/restoration complex: A review. *J Calif Dent Assoc* 34(2):122-8, February 2006.
42. Litonjua LA, Andreana S, et al, Tooth wear: Attrition, erosion, and abrasion. *Quintessence Int* 34(6):435-46, 2003.
43. Walton TR, A 10-year longitudinal study of fixed prosthodontics: Clinical characteristics and outcome of single-unit metal-ceramic crowns. *Int J Prosthodont* 12:519-26, 1999.
44. Brune D, Metal release from dental biomaterials. *Biomaterials* 7(3):163-75, May 1986.
45. Donovan TE, Chee WW, Cervical margin design with contemporary esthetic restorations. *Dent Clin North Am* 48(2): vi, 417-31, 2004.
46. Rosenstiel SF, Land MF, et al, Chapter 24, Metal ceramic restorations in Contemporary Fixed Prosthodontics, 4th ed. St Louis, Mosby Elsevier, 2006.
47. Tooth preparations in fundamentals of fixed prosthodontics, 3rd ed. Chicago, Quintessence Books, 1997.
48. Neiva G, Yaman P, et al, Resistance to fracture of three all-ceramic systems. *J Esthet Dent* 10(2):60-6, 1998.
49. Stappert CF, Guess PC, et al, All-ceramic partial coverage premolar restorations. Cavity preparation design, reliability and fracture resistance after fatigue. *Am J Dent* 18(4):275-80, 2005.
50. Guazzato M, Albarky M, et al, Strength, fracture toughness and microstructure of a selection of all-ceramic materials. Part I. Pressable and alumina glass-infiltrated ceramics. *Dent Mater* 20(5):441-8, 2004.
51. Anusavice KJ, Chapter 21, Dental Ceramics in Anusavice KJ, Phillips' Science of Dental Materials, 11th ed. St. Louis, W.B. Saunders Co., 2003.
52. Goldin EB, Boyd NW, et al, Marginal fit of leucite-glass pressable ceramic restorations and ceramic-pressed-to-metal restorations. *J Prosthet Dent* 93(2):143-7, February 2005.
53. Malament KA, Grossman DG, The cast glass-ceramic restoration. *J Prosthet Dent* 57(6):674-83, 1987.
54. Helvey GA, Fabrication of aesthetic, pressed, porcelain-fused-to-metal restorations. *Pract Proced Aesthet Dent* 14(6):487-92, 2002.
55. Sutton AF, McCord JF, Variations in tooth preparations for resin-bonded all-ceramic crowns in general dental practice. *Brit Dent J* 191(120):677-81, 2001.
56. Harris EF, Hicks JD, A radiographic assessment of enamel thickness in human maxillary incisors. *Arch Oral Biol* 43(10):825-31, 1998.
57. Atsu SS, Aka PS, et al, Age-related changes in tooth enamel as measured by electron microscopy: Implications for porcelain laminate veneers. *J Prosthet Dent* 94(4):336-41, 2005.
58. Magne P, Douglas WH, Cumulative effects of successive restorative procedures on anterior crown flexure: Intact versus veneered incisors. *Quintessence Int* 31(1):5-18, January 2000.
59. Gonzales-Lopez S, DeHaro-Gasquet F, et al, Effect of restorative procedures and occlusal loading on cuspal deflection. *Oper Dent* 31(1):33-8, 2006.
60. Freaedani M, Redemagni M, An 11-year clinical evaluation of leucite-reinforced glass-ceramic crowns: A retrospective study. *Quintessence Int* 33:503-10, 2002.
61. Sorensen JA, Choi C, et al, IPS Empress crown system: Three-year clinical trial results. *J Calif Dent Assoc* 26(2):130-6, 1998.
62. Kramer N, Frankenberger R, Clinical performance of bonded leucite-reinforced glass-ceramic inlays and onlays after eight years. *Dent Mater* 21:262-71, 2005.
63. Raigrodski AJ, Clinical and laboratory considerations for the use of CAD/CAM Y-TZP-based restorations. *Pract Proced Aesthet Dent* 15(6):469-76, 2003.
64. Picconi C, Maccauro G, Zirconia as a ceramic material. *Biomater* 20:1-25, 1999.
65. Luthardt RG, Holzhuter M, et al, Reliability and properties of ground Y-TZP-zirconia ceramics. *J Dent Res* 81(7):487-91, July 2002.
66. Heffernan MJ, Aquilino SA, et al, Relative translucency of six all-ceramic systems. Part I: Core materials. *J Prosthet Dent* 88:4-9, 2002.
67. Heffernan MJ, Aquilino SA, et al, Relative translucency of six all-ceramic systems. Part II: Core and veneer materials. *J Prosthet Dent* 88:10-15, 2002.
68. Snow SR, Repeatable alignment — Part II: Consistent photographic alignment accuracy. *Pract Proced Aesthet Dent* 15(7):551-7, August 2003.
69. Spear FM, The esthetic correction of anterior dental malalignment conventional versus instant (restorative) orthodontics. *J Calif Dent Assoc* 32(2):133-41, February 2004.
70. Spear FM, Kokich VG, Mathews DP, Interdisciplinary management of anterior dental esthetics. *J Am Dent Assoc* 137(2):160-9, February 2006.
71. Spear FM, The metal-free practice: Myth? Reality? Desirable goal? *J Esthet Restor Dent* 13(1):59-67, 2001.

TO REQUEST A PRINTED COPY OF THIS ARTICLE, PLEASE CONTACT Stephen R. Snow, DDS, Snow Dental Care, 909 San Ramon Valley Blvd., #216, Danville, CA 94526.

CDA JOURNAL, VOL 35, Nº7

Clinical Crown Lengthening in the Esthetic Zone

PAULO M. CAMARGO, DDS, MS; PHILIP R. MELNICK, DMD; AND LUCIANO M. CAMARGO, DDS, MSED

ABSTRACT Periodontal surgical procedures consisting of gingival flaps and osseous recontouring are indicated for crown lengthening of several contiguous teeth in the esthetic zone; both in cases where restorations are required and in cases where no restorations are planned, such as in patients with excessive gingival display due to altered passive eruption. Forced tooth eruption via orthodontic extrusion is the technique of choice when clinical crown lengthening is necessary on isolated teeth in the esthetic zone.

AUTHORS

Paulo M. Camargo, DDS, MS, is an associate professor of periodontics, University of California, Los Angeles, School of Dentistry, and in private practice in Los Angeles.

Philip R. Melnick, DMD, is a lecturer in periodontics, UCLA School of Dentistry, and in private practice in Cerritos, Calif.

Luciano M. Camargo, DDS, MSED, is an adjunct professor of prosthodontics, University of Paraná School of Dentistry, and in private practice in Curitiba, Brazil.

Clinical crown lengthening refers to procedures designed to increase the extent of supragingival tooth structure for restorative or esthetic purposes.[1] Clinicians often encounter the need for crown lengthening in the practice of dentistry (**TABLE 1**) and have to make treatment decisions taking into consideration how to best address the biological, functional, and esthetic requirements of each particular case.

Often, the need for crown lengthening is dictated by restorative dental procedures requiring margin placement in close proximity to the alveolar bone crest, violating the supracrestal area of the periodontal attachment regarded as the biologic width.[2] In the posterior segments, the esthetic consequences of crown lengthening are of lesser concern. In these cases, periodontal surgery consisting of gingival flaps and osseous resective surgery is the technique of choice to create space for the biologic width to be re-established at a more apical level, allowing for proper placement of the restorative margin.

However, when crown lengthening becomes necessary in the esthetic zone — particularly the upper anterior segment — the clinician must be cautious in making the appropriate diagnosis and in selecting a treatment technique that takes into consideration not only the functional, biological, and restorative needs of the tooth or teeth in question, but that also results in acceptable esthetics. While conventional periodontal surgery consisting of flaps and osseous recontouring are applicable, technical modifications are often required to ensure a satisfactory esthetic outcome. Also, the clinician must be able to recognize the specific situations when orthodontic extrusion rather than periodontal surgery is the preferred treatment.

The need for clinical crown lengthening in the esthetic zone may not be related to restorative dental procedures.

TABLE 1

Indications for clinical crown lengthening.

Subgingival fracture
Subgingival caries
Endodontic/pin/post perforation
Root resorption
Inadequate axial height for restoration retention
Unequal gingival levels
Esthetically short crowns due to tooth wear
Altered passive eruption

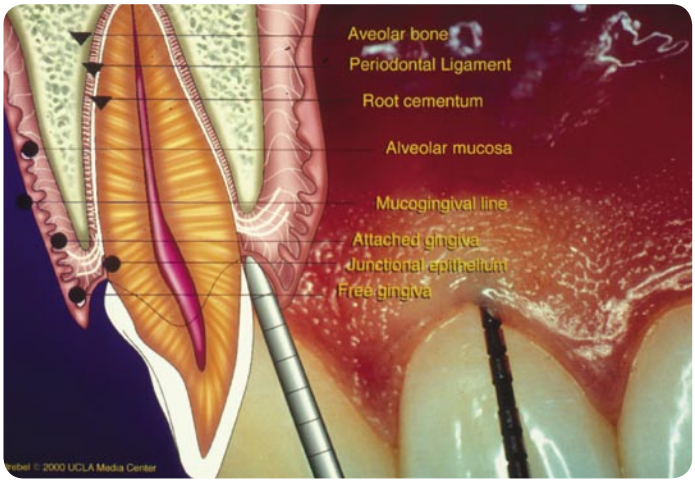


FIGURE 1. Clinical and schematic representation of a fully erupted tooth in the absence of attachment loss. Notice that the space between the alveolar crest and the cementoenamel junction is occupied by soft tissue directly attached to the tooth surface, which is referred to as the biologic width.

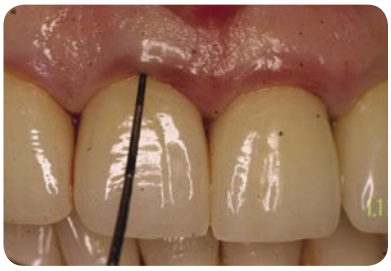


FIGURE 2. Violation of the biologic width: Restoration margins on teeth Nos. 8 and 9 were placed 4 mm subgingivally in close proximity to the alveolar bone. Notice the inflammatory changes on the marginal gingiva.

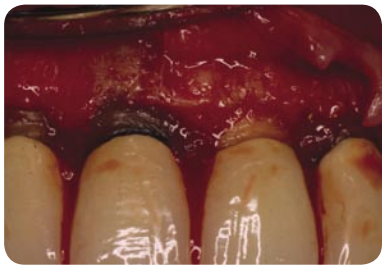


FIGURE 3. Case shown in Figure 2 following elevation of a buccal flap. Notice the minimum distance between the restoration margin and the crest of the alveolar bone.

There are patients who present with excessive gingival display upon smiling (also referred to as "gummy smile") and the reduction of this excessive display is desirable for the purpose of improving esthetics. While there are several possible etiologies involved in excessive display of the gingival tissues upon smiling, cases in which teeth present with incomplete eruption (also referred to as altered passive eruption) are most amenable to successful treatment with surgical crown lengthening.

Biologic Width: Definition, Clinical Relevance, and Violation Consequences

The concept of the biologic width was first originated by research conducted by Gargiulo, Wentz, and Orban where the distance between the apical end of the gingival sulcus and the crest of the alveolar bone was measured on several cadaver specimens.[2,3] In areas that present with periodontal health, that distance, now regarded as the biologic width, was reported to be an average of 2.04 mm, where approximately 0.97 mm is occupied by the junctional epithelium and 1.07 mm is occupied by connective tissue attachment to the root surface.

There is a reported wide range of possible locations of the biologic width along the tooth surface on a fully erupted tooth in the absence of attachment loss. Radiographically, it has been shown that the average distance between the cementoenamel junction and the bone crest varies between 0.4 mm (in which case the junctional epithelium is attached to enamel) and 1.9 mm (in which case the junctional epithelium is attached to cementum) in one study and between 0.5 mm and 2 mm in another study.[4,5] The average discrepancy between radiographic data and clinical data on the actual distance between the CEJ and the bone crest is 0.46 mm, suggesting a reasonable accuracy of the radiographic data.[6] It is also likely that the location of the biologic width migrates apically along the tooth surface throughout life, even in the absence of attachment due to continuous eruption of teeth, which happens as a consequence of occlusal wear.[3]

Therefore, the physiologic location of the biologic width can vary with age, tooth migration due to loss of arch or occlusal integrity, or orthodontic treatment. Taken all together, it is obvious there is significant variation in the data attempting to document the physiologic position of the alveolar bone crest in relation to the CEJ and, for the purpose of discussion in this manuscript; it will be assumed the marginal crest of the alveolar bone is physiologically located approximately 2 mm apical to the CEJ. The coronal end of the junctional epithelium is therefore coincident with the CEJ (FIGURE 1) on a fully erupted tooth where no loss of attachment has occurred.

With respect to the biologic width measurement, it should also be considered that 2.04 mm was an average for the study population and substantial variations occur among individuals

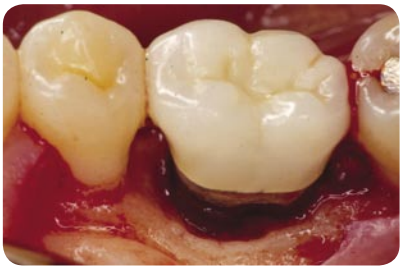


FIGURE 4. Bone resorption in form of a vertical defect that occurred originally as a response to a violation of the biologic width by the improper placement of a restoration margin. Even though there is now enough root surface area for a new biologic width to develop, the site is susceptible to plaque accumulation and the development of inflammatory periodontal diseases caused by bacteria.

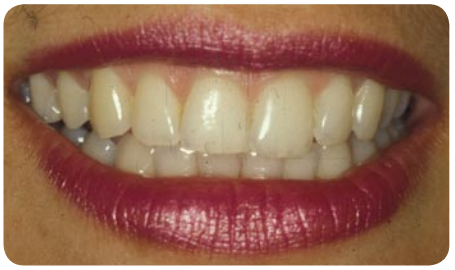


FIGURE 5. In a well-balanced smile, there is limited display of the upper gingival tissues.

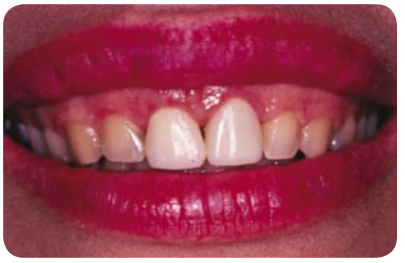


FIGURE 6. Example of excessive gingival display upon smiling. A "gummy smile" is a cause of esthetic complaints by patients.

(±30 percent).[3] It has been shown that the biologic width is approximately 2 mm in 85 percent of the population.[7] In approximately 13 percent of the population, that distance exceeds 2 mm while the same distance is less than 2 mm in 2 percent of the individuals examined.[7] Therefore, it should be remembered that the only precise technique to measure the biologic width on a particular patient is to perform bone sounding under local anesthesia in a periodontally healthy site. The commonly used 2 mm biologic width rule can be misleading if used empirically in the treatment of all cases.

Violation of the biologic width is a common occurrence in the practice of restorative dentistry. A familiar clinical situation in which the biologic width can be violated is by the placement of a deep subgingival restoration. The need to establish a subgingival restorative margin can be dictated by caries, tooth fracture, external root resorption, or the need to increase axial height of a tooth preparation for retention purposes.

If the apical margin of the restorative preparation is placed within the biologic width (i.e., too close to the bone), a zone of chronic inflammation is likely to develop[8] (**FIGURES 2-3**). The precise mechanism for chronic inflammation to develop in a scenario where the restorative margin is placed within the biologic width area is not fully agreed upon. One of the theories proposed is that there is insufficient space for a "normal" length junctional epithelium to develop; the junctional epithelium is short, weak, and does not exert an effective sealing effect of the dentogingival unit.[9] Moreover, the area is easily damaged by mechanical oral hygiene practices, and chronic inflammation persists or is easily induced. Others believe a deeply placed subgingival restorative margin, close to the alveolar bone crest, impairs proper plaque control promoting inflammatory changes not conductive to a healthy periodontal environment.[10]

There is still a third theory regarding the consequences of biologic width violation by the apical placement of restorative margins. It is argued that the biologic width, while violated at first, will naturally redevelop in a more apical position at the expense of further bone resorption that occurs following preparation of the tooth and establishment of a restorative margin.[7] Interestingly, these effects of such bone resorption are often closely related to the patient's periodontal biotype. Chronic inflammation in a thin biotype may result in bone loss and gingival recession. In a thick biotype, such bone resorption might occur in the form of a vertical osseous defect (**FIGURE 4**) that will lead to difficulties in plaque removal by the patient and the development of plaque-induced inflammatory conditions of the periodontium.

In summary, there is no clinically or scientifically sound justification to ignore the biologic width as an anatomical and functional entity in the practice of restorative dentistry. While the actual cause for the development of chronic inflammation in areas where the biologic width is violated may not be precisely understood, the consequences of its violation in inducing inflammatory changes to the periodontium are well documented. Therefore, it is essential the interaction between restorative procedures and the biologic width be understood, and properly addressed by the clinician when treating patients.

The Gingival Scaffold as an Integral Component of a Well-balanced Smile

The upper anterior segment is by far the area of the dentition with the most esthetic implications. As such, clinical situations with esthetic relevance described in this paper will primarily refer to the upper anterior segment.

Books have been dedicated to the description of all elements involved in an esthetically pleasant, well-balanced smile.[11,12] While a detailed discussion about smile esthetics escapes the scope of this article, a brief description of the role played by the position and symmetry of the gingival scaffold in the overall context of an esthetically well-balanced smile is pertinent to the topics described in this manuscript.

In general, it is commonly accepted that up to 2 mm of gingival tissue be displayed upon a full smile[13] (**FIGURE 5**). While display of less than 2 mm of gingival tissue might occasionally constitute an esthetic concern for patients, the display of more than 2 mm of gingival tissue (**FIGURE 6**) is often a reason for patients to seek treatment with the objective of

CDA JOURNAL, VOL 35, Nº7

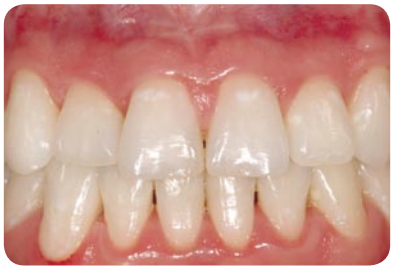


FIGURE 7. Ideal position of the gingival scaffold on the upper anterior segment. Notice the gingival line position is more coronal on the lateral incisors as compared to the central incisors and canines.

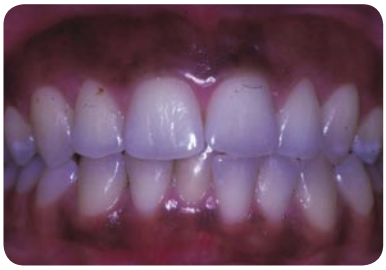


FIGURE 8. Anterior view of a case in which the gingival line is present at the same apico-coronal level on the central and lateral incisors and the canines. This gingival profile, even though not ideal, does not constitute a significant violation of the esthetic parameters of a well-balanced smile.

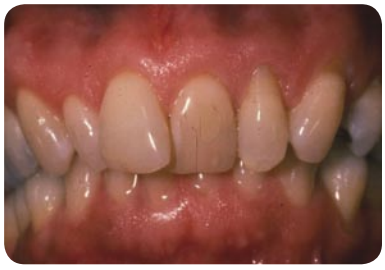


FIGURE 9. Anterior view of a case in which the gingival margin position on the upper left lateral incisor is more apical than on the central incisors. This gingival profile is not acceptable from the esthetic standpoint.

decreasing gingival display. The etiologies of excessive gingival display and its treatment options are described later in this article. The presence of the gingival margin in a position that is too coronal is one of the etiologies that may result in excessive gingival display upon smiling.

It is also accepted that the position of the gingival margin on upper canines and central incisors is ideally parallel to the inter-pupillary line. However, the gingival margin position on upper lateral incisors is often located slightly coronal to the gingival line position on upper central incisors and canines (**FIGURE 7**). While a slight deviation from the parallel position of the gingival line to the inter-pupillary line does not usually constitute a noticeable esthetic compromise (**FIGURE 8**), having the gingival line on upper lateral incisors positioned apical to the gingival line position on upper central incisors and canines is considered less acceptable from the esthetic standpoint (**FIGURE 9**).

The position of the gingival margin should be symmetric on both sides of the esthetic zone. Discrepancies in the position of the gingival margin on different elements of the same tooth group (i.e., upper right and left central incisors) are easily caught by causal observation and should not be overlooked in analyzing and performing dental treatment in the esthetic zone.

Finally, the ideal gingival contour is scalloped in shape and soft tissue papillae fully occupy the interproximal embrasures. Treatment that results in a less scalloped, flatter gingival margin will often result in shorter interdental papilla and the opening of the embrasure spaces (i.e., generation of "black triangles"). This constitutes an easily observable esthetic breach and may require closure by restorative procedures with long contact surfaces.

The clinical relevance of various magnitudes of less-than-ideal position and symmetry of the gingival scaffold in the esthetic zone has been evaluated through research.[14] Despite the fact the patient's observational capabilities appear to be fairly tolerant to small gingival discrepancies present in the esthetic zone, basic esthetic principles should be followed in treatment procedures including crown lengthening because noticeable thresholds can be clearly exceeded and result in unacceptable treatment endpoints from the esthetic standpoint.

Crown Lengthening in the Esthetic Zone

Clinical situations in which crown lengthening is indicated in the esthetic zone can be classified into two basic types: restorative cases, where placement of restorations will follow the execution and healing of the crown lengthening procedure; and nonrestorative cases where no restorations of the teeth being lengthened are planned. The treatment approaches utilized in restorative and nonrestorative cases differ significantly, and for that reason will be discussed separately. Further, crown lengthening in restorative cases in the esthetic zone might be necessary on several contiguous teeth (i.e., the whole upper anterior segment) or on isolated teeth, and the clinical management of those two case types also differ substantially. A treatment decision tree for teeth requiring crown lengthening in the esthetic zone is presented on **TABLE 2**.

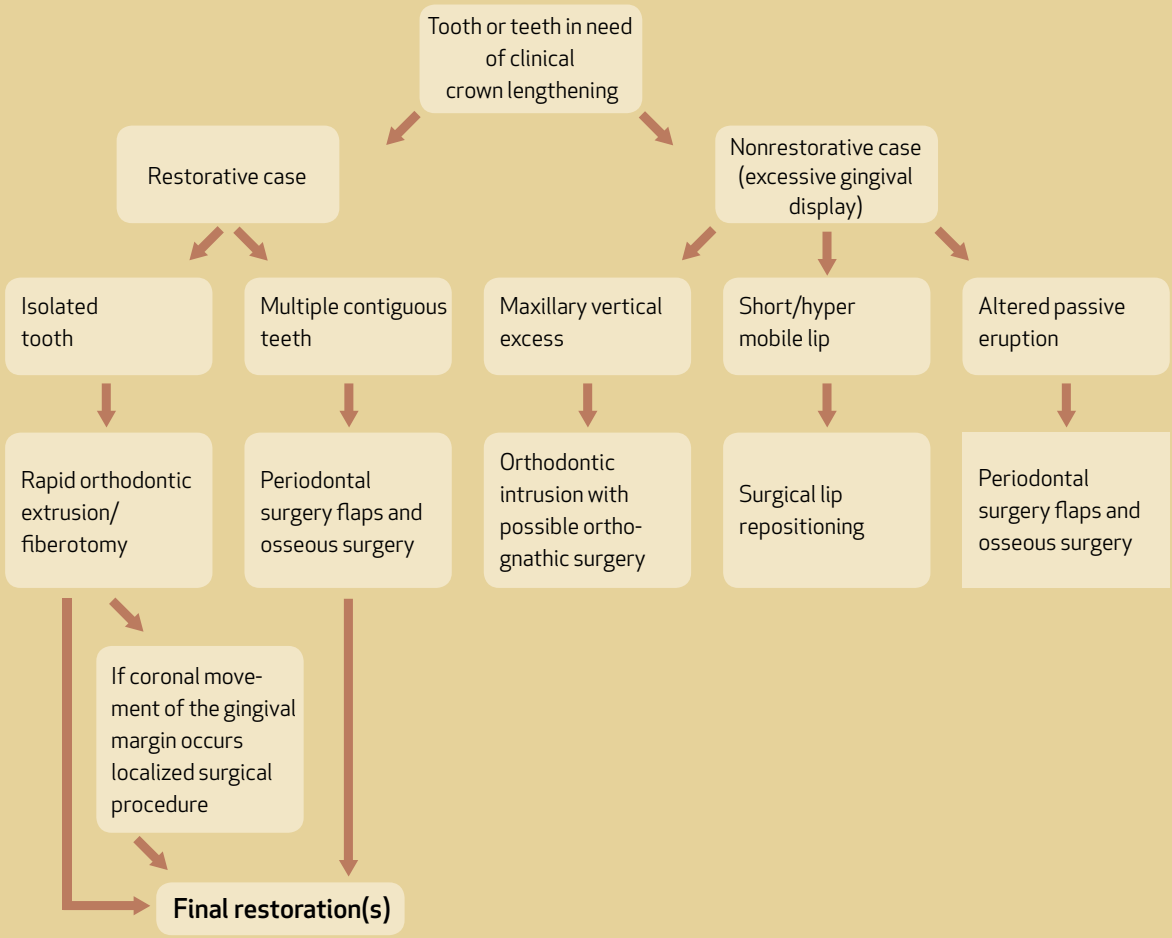
Crown Lengthening in Restorative Cases: Multiple Contiguous Teeth

The need for clinical crown lengthening of the upper anterior segment prior to placement of restorations can be a result of caries, external root resorption, tooth fracture, or the need to increase the axial height of teeth for restoration retentive purposes. In any of these situations, tooth preparation to the desired level in the apical direction may result in violation of the biologic width.

The basic concept of crown lengthening for restorative ease is to surgically "move" the bone crest to a more apical position, providing for sufficient coronal tooth structure for restoration, while allowing space for re-establishment of a new physiologic dentogingival dimension (biologic width). It should be remembered that the distance between the gingival margin and the crest of the bone is genetically determined.[3] Therefore, the soft tissue regrows to its genetically predetermined height in relation to the bone, whether or not bone profile has been modified in the crown lengthening procedure. On the other hand, the position

TABLE 2

Treatment decision tree for a tooth or teeth requiring clinical crown lengthening in the esthetic zone.



of the gingival margin in relation to the tooth surface is dictated by the position of the alveolar bone. Soft tissue rebound is therefore determined by the position of the underlying bone and is independent from the restorative treatment performed.

Treatment planning of restorative cases requiring crown lengthening in the esthetic zone should be initiated by a diagnostic wax-up mimicking the future goals to be achieved by the crown lengthening procedure and the size and shape of the final restorations. From the esthetic standpoint, attention should be paid to the proposed final position of the incisal edge (tooth exposure, phonetics), crown length, as well as to the apico-coronal/mesiodistal proportion of the clinical crowns of the teeth being treated. Because lengthening through a periodontal surgical procedure increases the apico-coronal crown dimension, the final restorations may (if esthetic, phonetic, and occlusal demands permit) require incisal reduction in order to maintain proper apico-coronal/mesiodistal proportion.

Ideally, prior to the crown lengthening procedure, preliminary preparation of the teeth to be treated should be conducted by the restorative dentist followed by placement of temporary restorations. The margins of the temporary restorations should be placed in healthy tooth structure and as close to the position of the final restoration as possible. Having a preliminary delineation of the final position of the restorative margins is useful in guiding the surgeon as to the extent of osseous recontouring required. Also, the execution of the surgical procedure is facilitated by the removal of the temporary restorations.

The technique of choice for crown lengthening of multiple contiguous teeth in the upper anterior segment where restorations will be delivered is the apically positioned flap combined with resective osseous surgery (FIGURES 10A-B). The surgical procedure includes the elevation of a buccal flap combined or not with a palatal flap, depending on the need for crown lengthening on the palatal and interproximal aspects of the teeth being treated. In cases where both a buccal and a palatal

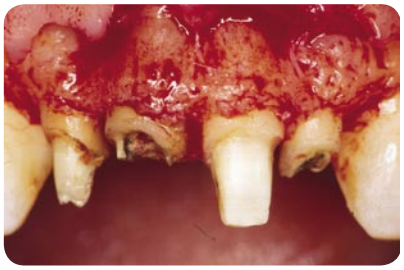


FIGURE 10A. Osseous profile of teeth Nos. 7 through 10 following flap reflection and soft tissue degranulation. Notice minimal exposure of tooth structure coronal of the alveolar bone level.

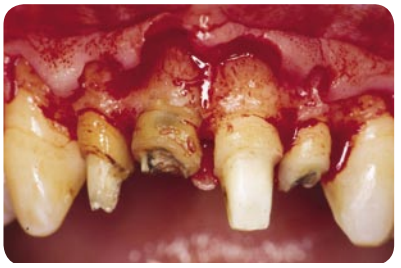


FIGURE 10B. Osseous resection was performed around teeth Nos. 7 through 10 as to expose a minimum of 3 mm or tooth structure.

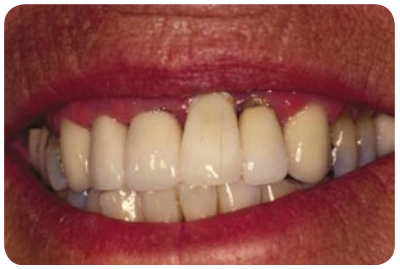


FIGURE 11. Clinical crown lengthening of an isolated tooth in the upper anterior segment results in gingival margin asymmetry and unacceptable esthetic results.

flap are elevated, degranulation of the interproximal spaces is performed. Initial incisions on the buccal aspect of the teeth to be lengthened can be apical to the gingival margin and scalloped in shape if there is an abundance of keratinized tissue. The initial incision may be placed close to or in the gingival sulcus in cases where the dimensions of the keratinized tissue are limited (<3 mm). In designing the flap, an attempt should made to create surgical papillae that are relatively thick and long, so that a well-scalloped gingival line with the presence of full papillae develops following healing. This reduces the need to fabricate final restorations that, in order to close wide postoperative interproximal spaces, have long contact surfaces and tend to be excessively rectangular rather than triangular in shape. The palatal flap employs scalloped incisions combined with thick and long surgical papillae, similar to the buccal flap.

The buccal flap should be reflected apical to the mucogingival junction as to expose the alveolar bone where recontouring is necessary and also to allow for flap mobility. The palatal flap should be reflected sufficiently to allow for adequate access for osseous recontouring. All gingival tissues left in contact with the teeth and bone following elevation of the flaps should be removed with the use of curettes and sonic/ultrasonic devices. Scaling and root planing of the teeth involved in the surgery should also be performed if clinical inspection reveals the presence of calculus.

Osseous recontouring is usually performed with a high-speed handpiece under copious water spray. The rear-exhaust handpiece has been recommended in order to minimize the possibility of air embolism. Osteoplasty refers to the removal of nonsupporting bone and is the first step in the osseous recontouring process.[15] Buccolingual reduction of the alveolar housing is achieved with the use of round burs and is more pronounced in the interproximal areas than on the direct buccal and lingual surfaces of the teeth. An ostectomy is the removal of supporting bone and it can be performed with the use of end-cutting burs and/or osseous chisels.[15]

The amount of ostectomy to be performed depends upon the future position of the restoration margins and the biologic width for that particular patient. As stated before, the most precise technique to determine the biologic width for a particular patient is to perform transgingival bone sounding under local anesthesia in periodontally healthy areas. It is important to perform bone sounding on straight (buccal and/or lingual) and interproximal areas, as measurements may differ. This data can be used to determine the space that will be required for the reformation of the supracrestal tissues. As previously noted, that is anticipated to be in the magnitude of 2 mm. An ostectomy should be performed as to create a distance between the restoration margin and the alveolar crest that is slightly (1 mm) greater than the premeasured dimension of the biologic width for that patient in order to account for further apical displacement of the restorative margin during the final preparation of the teeth. For instance, if the biologic width for a particular case is 2 mm, the clinician should create a space ≥ 3 mm between the temporary restoration margin and the crest bone so that a "margin of safety" is built into the procedure in case the restoration margin needs to placed in a more apical position.

Teeth with extensive coronal damage, such as those in which endodontic treatment have been performed and a core has been placed, may require a greater extent of tooth structure exposure in crown lengthening procedures. Therefore, a greater amount of ostectomy may be necessary on such teeth. That requirement exists because a minimum of 1 to 2 mm of natural tooth structure coronal to the preparation line is recommended for the restoration to exert a ferrule effect on the tooth, which aids in retention and reducing the risk of a future root fracture.[16]

Another important point in the osseous recontouring process is the establishment of positive osseous architecture with the resective procedure.[17] Often, the need for ostectomy is more pronounced in the interproximal areas than on the direct buccal and lingual areas, and that interproximal osseous resection should be accompanied by ostectomy on the direct buccal and/or lingual surfaces so that the direct buccal and lingual bone levels are more apical than the interproximal levels of the alveolar bone. The average facial–interproximal bone scallop of a maxillary central incisor is approximately 3 mm. Negative osseous architecture (i.e., the buccal and/or

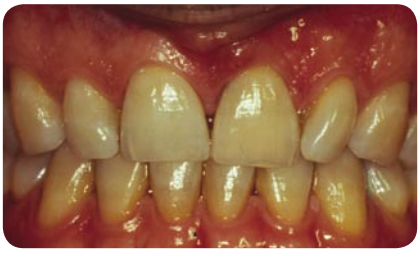


FIGURE 12A. Clinical view of tooth No. 9, which presented with external root resorption on its mesial aspect and required clinical crown lengthening prior to restoration. *(Courtesy of Dr. Bruce J. Crispin, Tarzana, Calif.)*

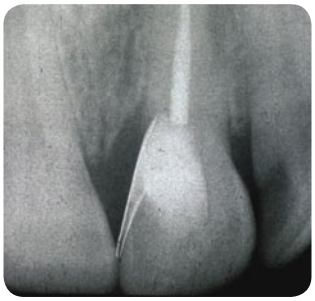


FIGURE 12B. Radiographic view of tooth No. 9 shown on Figure 12a. Notice the proximity of the apical end of the resorption area and the interproximal bone crest.

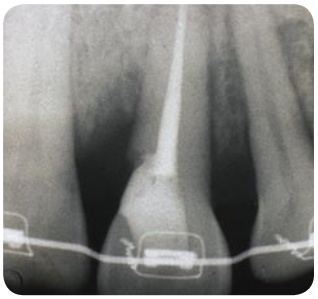


FIGURE 12C. Radiographic view of tooth No. 9 shown on Figure 12a three weeks after forced eruption through conventional orthodontics. Compare the relationship between the resorption area and the interproximal bone crest prior to the extrusion (Figure 12b) and after the extrusion.

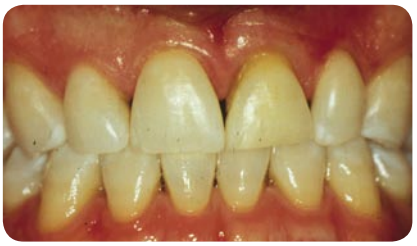


FIGURE 12D. Clinical view of the upper anterior segment of the case first shown on Figure 12a after completion of the orthodontic extrusion and prior to the delivery of the final restoration. Observe also the smaller diameter of the root of tooth No. 9 at the gingival line level as compared to that of tooth No. 8; the restorative correction of this discrepancy can be challenging.

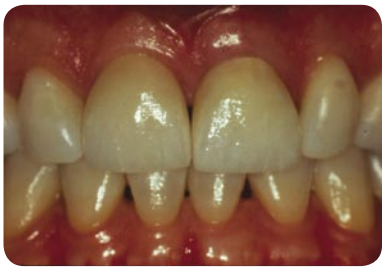


FIGURE 12E. Clinical view of the final restorations on the case first shown on Figure 12a.

lingual bone being more apical than the interproximal bone) is likely to lead to interproximal periodontal "pocketing" following healing of the surgical procedure.

Flap suturing is performed as to secure the soft tissue in intimate contact with the crest of the bone and the newly exposed root. The temporary restorations are cemented and the use of periodontal dressing is optional. Sutures are removed at the end of the first operative week when mechanical oral hygiene is initiated.

An important aspect of the healing of surgical crown lengthening procedures is related to the length of the time period between the surgical procedure and the final preparation and impression-making of the teeth. Of direct clinical importance is the stability of the postoperative position of the gingival margin. Premature final tooth preparation may lead to final restorative margins located supragingival, if further gingival recession occurs as a result of healing.

Rosenberg has suggested a six-month wait between the surgical appointment and the final preparation and impression-making of the teeth.[18] Pontoriero and Carnevale studied the final position of the gingival margin following osseous resection in crown lengthening procedures and noticed that changes can occur up to 12 months after surgery.[19] If esthetics becomes a problem during the healing period because of supragingival temporary restoration margins and coincident root exposure, an intermediate preparation step and temporary restoration relining can be performed prior to the final preparation and impression-making appointment. This intermediate step should not however be performed for at least six weeks following the surgical procedure to allow for early healing of the dentogingival complex and prevent the inadvertent dislodgement of foreign bodies such as restorative materials and cement under the gingival tissues and in contact with bone. The new intermediate finish line should be no closer than 4 mm from osseous crest to provide adequate space for healing without encroachment on the newly forming biologic width. Once soft tissue maturation is complete (six to 12 months postoperatively) the final preparation can be accomplished, terminating 0.5 mm intracrevicularly.[17]

The gingivectomy technique can only be utilized for crown lengthening purposes in the esthetic zone in situations where there is horizontal bone loss and/or increased soft tissue depth, and adequate keratinized gingiva. Treatment of such cases with the gingivectomy technique serves the dual purpose of eliminating excessive supracrestal tissue and elongating clinical crowns. However, any case in which osseous recontouring is required to achieve crown lengthening cannot be adequately treated by the gingivectomy procedure. Removal of the supracrestal soft tissues alone will simply result in a regrowth of the predetermined biologic dimension, with no net gain in crown length. The risk is that the illusion of adequate crown length will prompt early tooth restoration, but now in close proximity to bone crest. The inevitable reformation of the supracrestal gingival tissue complex results in a situation to be avoided at the outset; a deep subgingival restorative margin in close proximity to bone crest and infringement of biologic width.

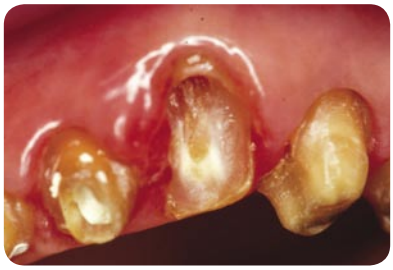


FIGURE 13A. Clinical view of tooth No. 11 after caries removal showing violation of the biologic width on the mesial aspect.

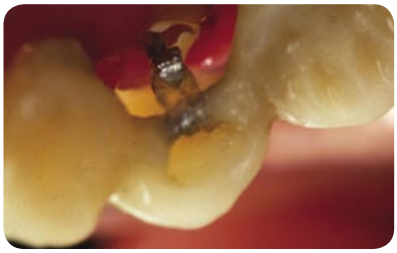


FIGURE 13B. Forced tooth eruption was conducted utilizing a metal wire within the temporary restoration as anchorage for an orthodontic elastic also attached to an intra-radicular post.

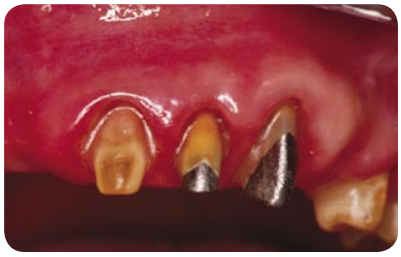


FIGURE 13C. Clinical view of tooth No. 11 first shown on Figure 13a at the time of its final preparation and impression-making, 12 weeks after the active phase of the orthodontic extrusion was completed. Notice the excellent gingival health on the mesial aspect of tooth No. 11 with no violation of the biologic width.

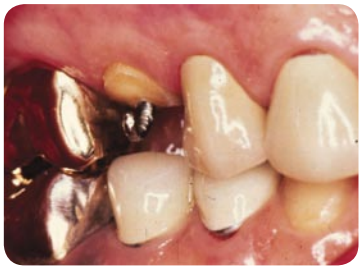


FIGURE 14A. Clinical view of tooth No. 4, which required clinical crown lengthening due to a subgingival fracture. If treated with a surgical approach, the crown margin on tooth No. 5 would become supragingival and pose an esthetic concern. Forced tooth eruption of tooth No. 4 was the treatment of choice. *(Courtesy of Dr. John B. Avera, Aptos, Calif.)*

FIGURE 14B. A device resembling the frame of a removable partial denture was fabricated. The device sat passively on the teeth adjacent to tooth No. 4 and served as anchorage for an orthodontic elastic also attached to an intraradicular post.

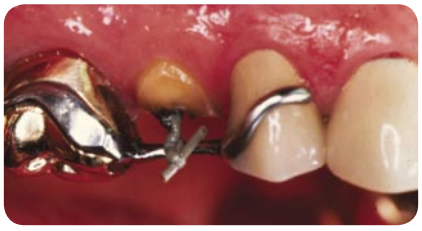


FIGURE 14C. Orthodontic elastic activating the extrusion using the removable device as anchorage.

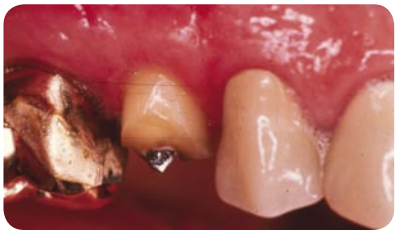


FIGURE 14D. Clinical view of tooth No. 4 first shown on Figure 14a at the conclusion of the orthodontic extrusion. Notice the increase in the clinical crown length on tooth No. 4 and no significant alteration in the position of the gingival margin on tooth No. 5.

Crown Lengthening in Restorative Cases: Isolated Teeth

Extreme care should be exercised when selecting periodontal surgery as the treatment modality to achieve crown lengthening of isolated teeth in the esthetic zone because it will often result in asymmetry of the gingival line (**FIGURE 11**). In these cases, forced tooth eruption via orthodontic extrusion presents with several advantages.

Forced tooth eruption via orthodontic extrusion aims at exposing more tooth structure to the supragingival environment while not altering the position of the gingival margin and the alveolar bone. In order to achieve such an objective, the orthodontic movement of nonvital teeth should utilize heavy forces and a quick onset.[20] Extrusion rates of 1 mm per week are commonly achieved when orthodontic forces of this magnitude are applied to teeth.

Forced tooth eruption can be performed via conventional fixed orthodontic appliances (**FIGURES 12A-E**), utilizing temporary restorations as anchorage for the orthodontic movement (**FIGURES 13A-C**) or by fabricating a device similar to the framework of a removable partial denture that sits passively on adjacent teeth, to which an orthodontic elastic can be activated every other day (**FIGURES 14A-D**).

In order to prevent the coronal movement of the gingival tissue and the alveolar bone during the course of the orthodontic extrusion, supracrestal fiberotomies have been suggested.[21] Under local anesthesia, severing of the supracrestal periodontal fibers is performed with a thin scalpel blade or a periotome on a weekly basis in order to decrease the tensile strength in the gingival tissues and bone.[22]

The majority of rapid orthodontic extrusions are performed on teeth that have been previously endodontically treated, and no periapical problems are associated with such movement even in the presence or endodontic overfill.[23] However, when rapid orthodontic extrusions are performed on vital teeth, rupture of the neurovascular bundle may occur and result in pulpal necrosis. Therefore, on vital teeth, slow orthodontic extrusion followed by a localized surgical procedure consisting of an apically positioned flap combined with osseous resective surgery is the treatment of choice to minimize the chances for pulpal necrosis.

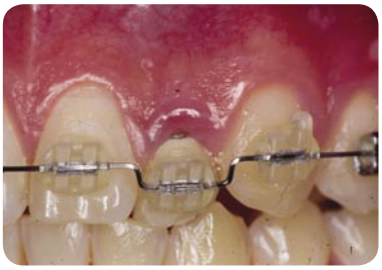


FIGURE 15A. Tooth No. 10 has been orthodontically extruded but the gingival margin has inadvertently migrated in the coronal direction. A localized resective surgical procedure is required to apically position the gingival margin on tooth No. 10 as to match that on tooth No. 7. *(Orthodontics by Dr. Eric Ting, Los Angeles.)*

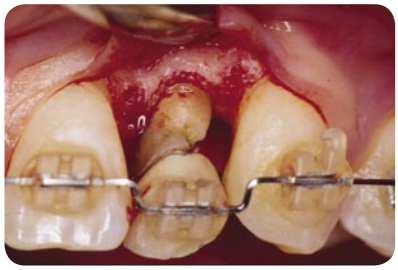


FIGURE 15B. Surgical treatment of the case first shown on Figure 15a. Following elevation of a gingival flap, minor osseous recontouring was performed.

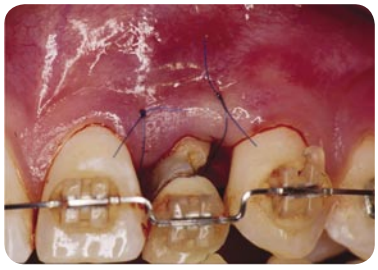


FIGURE 15C. Suturing of the surgical procedure shown on Figures 15a-b.

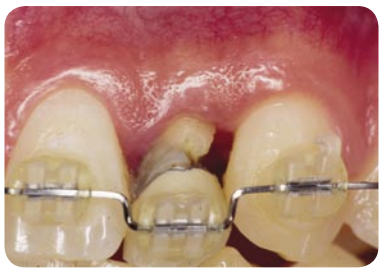


FIGURE 15D. Six-month postoperative view of tooth No. 10 (first shown on Figure 15a) prior to its final preparation and impression-making.

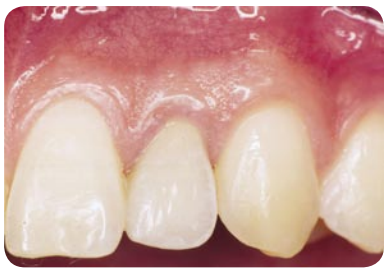


FIGURE 15E. Final restoration of tooth No. 10 first shown on Figure 15a with a porcelain-fused to metal crown. Notice the adequate position of the gingival margin in relation to teeth Nos. 9 and 11. *(Restorative dentistry by Dr. Ting-Ling Chang, Los Angeles.)*

Orthodontic retention is an important consideration following orthodontic extrusion. Retention periods should be based on the time necessary for periodontal fibers to reorganize. Principal fibers of the periodontal ligament reorganize in eight to nine weeks while supracrestal periodontal fibers do so in up to 12 weeks following active orthodontic movement. Therefore, a retention period lasting at least 12 weeks is indicated following orthodontic extrusion. Fiberotomies at the end of the active orthodontic extrusion have been suggested as means of preventing a postorthodontic treatment coronal migration of the gingival margin and bone.[24]

There are clinical situations in which coronal movement of the gingival margin occurs following rapid orthodontic extrusion despite all attempts to maintain the gingival margin in its original position. In those cases, a localized surgical procedure involving an apically positioned flap possibly combined with osseous resective surgery is indicated as a means to correct the discrepancy in the position of the gingival margin (**FIGURES 15A-E**).

A restorative challenge encountered on orthodontically extruded teeth is the dimension of the diameter of the root at the gingival margin level. By virtue of its conical shape, the root diameter of an extruded tooth at the gingival margin level is smaller than the correspondent tooth on the adjacent quadrant (**FIGURE 12D**). As a consequence, the emergence profile of the restoration to be delivered to such a tooth needs to compensate for that root diameter discrepancy and be slightly over contoured.

Crown Lengthening in Nonrestorative Cases

The need for crown lengthening in the esthetic zone where no restorative treatment is involved is usually related to excessive gingival display, often referred to as "gummy smile." When making treatment decisions regarding cases of excessive gingival display, a differential diagnosis is crucial in selecting the appropriate therapeutic approach. Excessive gingival display upon smiling may have three different causes.

In the first scenario, the patient may present with a genetically determined skeletal deformity, where the middle third of the face presents with excessive vertical length. This skeletal characteristic is commonly observed in patients who present with a class II/division II malocclusion. The appropriate treatment for these cases involves orthodontic treatment focusing on intrusion of the upper anterior teeth if the desired movement of the dentogingival complex in the apical direction does not exceed 3 mm (**FIGURES 16A-E**). Orthognathic surgery combined with orthodontic treatment is indicated for more severe cases where movement of the dentogingival complex in the apical direction of 4 mm or more is desirable. Surgical crown lengthening via periodontal surgery to reduce excessive gingival display in cases of skeletal deformities is not the ideal treatment, as it results in root exposure and requires restoration of the teeth involved.

The second situation in which excessive gingival display is observed involves cases of patients with short and/or hyper mobile lips (**FIGURE 17**). Lip dimensions and movement range are genetically determined traits and, up until recently, little could be done by the dental professional to improve these cases. Rosenblatt and Simon described a surgical technique involving

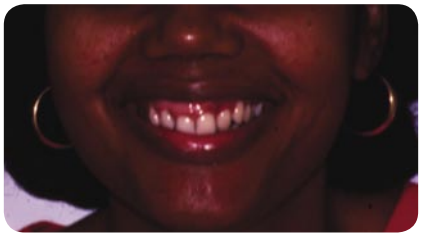


FIGURE 16A. This patient's main complaint was of excessive gingival display upon smiling. Clinical examination revealed that the cause of the problem was dentoskeletal in nature (vertical maxillary excess) and not of periodontal origin. The treatment of choice was orthodontic intrusion of the upper and lower anterior teeth. *(Courtesy of Dr. Patrick K. Turley, Santa Monica, Calif.)*

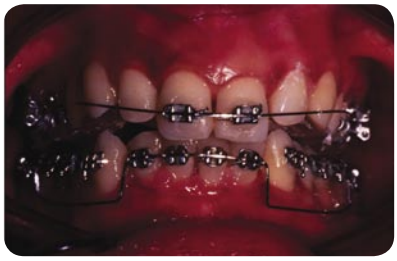


FIGURE 16B. Clinical view of the orthodontic appliance used to treat the case first shown on Figure 17a.

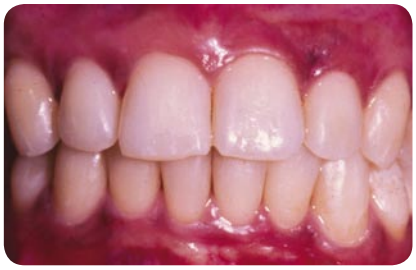


FIGURE 16C. Clinical view of the case first shown on Figure 16a at the conclusion of the orthodontic treatment. No periodontal surgical therapy was performed in treating this case.

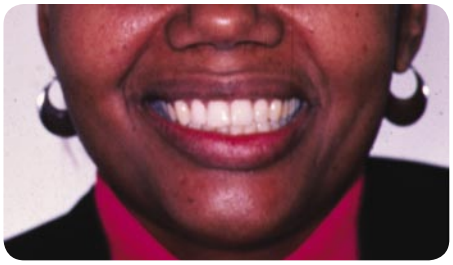


FIGURE 16D. Postorthodontic treatment view of the patient whose case was first shown on Figure 16a when smiling. Notice that the patient no longer presents with excessive gingival display as evident on Figure 16a.

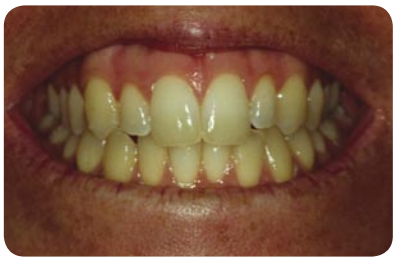


FIGURE 17. Excessive gingival display upon smiling because of a hyper mobile upper lip. The position of the gingival margin is adequate — slightly coronal to the cementoenamel junction — and periodontal surgical therapy is not indicated.

repositioning of the upper lip, thereby limiting its range of motion.[25] As a consequence of such a surgical intervention, less gingival tissue is displayed upon smiling. Again, crown lengthening of the upper anterior segment via periodontal surgery is not indicated in cases where excessive gingival display is caused by short and/or hyper mobile lips because it would result in root exposure and the need for restoration of the teeth involved, besides increasing the apico-coronal dimension of the clinical crowns of the teeth beyond the ideal apico-coronal/mesiodistal proportion.

Crown lengthening via periodontal surgery is the treatment of choice in cases where excessive gingival display is a result of altered passive eruption. The tooth eruption process can be divided into two distinct periods: active and passive eruption. Active eruption refers to the movement of the teeth in the coronal direction up to the point at which occlusal contacts are established. The active phase of eruption is followed by passive eruption where the gingival tissue and the alveolar bone margin move in the apical direction. By the end of adolescence, the eruption process is expected to be complete for most teeth (with the exception of third molars) and the gingival line is located 1 to 3 mm coronal to the CEJ, with the coronal end of the junctional epithelium being coincident with the CEJ. In some individuals, for unknown reasons, the passive phase of the eruption process does not occur or is incomplete. This phenomenon is referred to as altered passive eruption where the coronal margin of the alveolar bone is located close to (less than 2 mm) or at the level of the CEJ, which results in the gingival margin occupying a position more coronal to the CEJ than observed where the whole eruption process has occurred. The clinical crowns of teeth, in which altered passive eruption is present, tend to be square in shape and excess gingival tissue is displayed upon smiling.

Cases of altered passive eruption can be successfully treated with crown lengthening via periodontal surgery (**FIGURES 18A-E**). It should be kept in mind that a crucial determinant of the position of the gingival tissue is the underlying bone. Therefore, in order to apically position the gingival margin in a sustainable fashion, osseous resection is necessary. The surgical technique selected for crown lengthening procedures must provide the clinician with access to bone, and, as a function of that, the periodontal flap is the technique of choice. The gingivectomy technique, by virtue of not allowing access to the alveolar bone, is contraindicated for treatment of the majority of cases that present with altered passive eruption.

Because cases where surgical crown lengthening to treat altered passive eruption are frequently nonrestorative cases, any decrease in height of interdental papillae as a consequence of the surgical procedure needs to be prevented. The clinician treating these cases does not have the option of developing restorations with longer interproximal surfaces so as to close the iatrogenically created spaces. Therefore, it is prudent to elevate a buccal flap only, leaving the interproximal papillae and the palatal tissue intact so as not to embarrass blood supply to those tissues and conse-

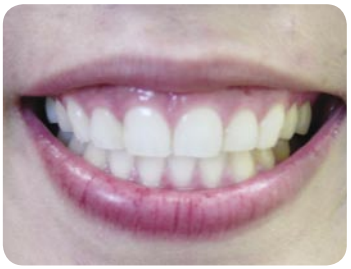


FIGURE 18A. Clinical view of a patient whose complaint was of a "gummy smile" and "square teeth." Clinical examination revealed the presence of altered passive eruption where the alveolar bone crest position was coincidental with the cementoenamel junction and the gingival margin was located 3-4 mm coronal to the CEJ. *(Case treated by Dr. Nelson T. Yen, Fullerton, Calif. and Dr. Paulo M. Camargo.)*

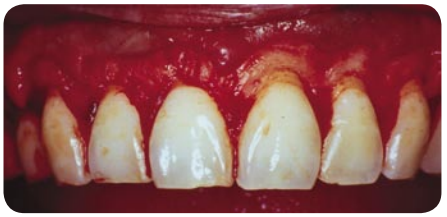


FIGURE 18B. Treatment of the case first shown on Figure 18a. Elevation of a buccal flap confirmed the excessive coronal position of the alveolar bone as shown on the upper right anterior segment. Osseous resection through osteoplasty and ostectomy was performed on the upper left anterior segment. Notice the decreased buccolingual dimension of the alveolar house and the increased distance between the bone margin and the cementoenamel junction on the upper left teeth.

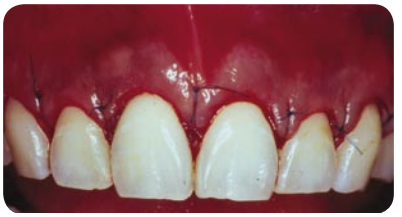


FIGURE 18C. Suture of the flap on the case first shown on Figure 18a.

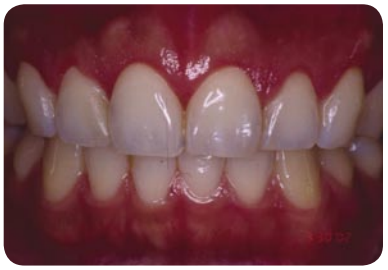


FIGURE 18D. Sixteen-week postoperative view of the case first shown on Figure 18a. Notice the esthetically acceptable vertical/horizontal proportion on all teeth of the upper anterior segment.

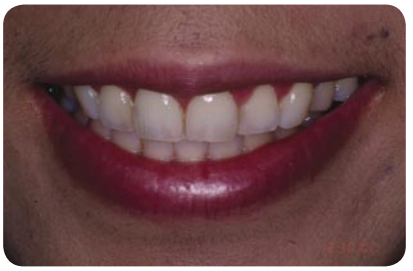


FIGURE 18E. Postoperative view of the patient whose case was first shown on Figure 18a. Notice the absence of excessive gingival display after treatment. (Compare to the preoperative photograph on Figure 18a.)

quently decrease the probability of tissue shrinkage. If lengthening of the clinical crowns is also desirable on the palatal aspect, the surgical procedure should be performed separately, leaving the buccal and interproximal tissues then undisturbed.

The periodontal flap utilized for the treatment of cases where altered passive eruption is present employs a reverse bevel incision. Most cases of altered passive eruption occur on patients who present with a thick periodontal biotype, where there is an abundance of keratinized tissue. Therefore, a scalloped incision can be usually used with minimal risk of creating mucogingival problems. It should be kept in mind that a minimum of 3 mm of keratinized tissue (2 mm attached, 1 mm nonattached) should exist following healing of the surgical procedure. Given there is abundance of keratinized tissue, the initial reverse bevel incision is made at the desired new level of the gingival margin, or about 1 mm coronal to the CEJ. A full thickness flap is elevated to the mucogingival junction as to expose the alveolar bone and is extended apical to the MGJ.

Osseous resection in cases of altered passive eruption follows basic principles of bone recontouring employed in the treatment of osseous defects associated with periodontitis or in the execution of surgical clinical crown lengthening on restorative cases as described previously. Because cases of altered passive eruption are often of the thick periodontal biotype, significant buccolingual reduction of the buccal bone through osteoplasty is required. This reduction is accomplished with high-speed carbide round burs under copious irrigation and is initiated by the creation of apico-coronal grooves in the interproximal areas; the transition between these grooves is made smooth by further osseous reduction over the direct buccal surfaces of the roots. Once osteoplasty is completed, an ostectomy is required along the most coronal end of the alveolar bone. An ostectomy is performed with high-speed end-cutting burs. When placed parallel to the long axis of the teeth, end-cutting burs do not cause damage to the root surfaces. An ostectomy should be performed as to create a distance of 2 mm between the crest of the bone and the CEJ.

This space will be occupied by the biologic width and the gingival margin will be located slightly coronal to the CEJ. Bone chisels and hand curettes can be used to finalize the osseous recontouring process. As cases of altered passive eruption may affect all teeth in the oral cavity, it is often not possible to determine the ideal dimension of the biologic width for that patient through bone sounding under local anesthesia as no "normal" periodontal site may be present. Therefore, the clinician needs to make an empirical decision as to the extent of the ostectomy to be performed, and a 2 mm distance between the CEJ and the alveolar crest is adequate in the majority of the cases. However, patients with a thick periodontal biotype exhibit significantly more soft tissue regrowth than those with a thin biotype, suggesting that in thick biotype patients additional bone removal may be beneficial in securing a stable long-term result. In addition, it is important to carry the bone recontouring process to the line angles, as failure to do so will often result in soft tissue rebound and a reduced crown lengthening result.

The buccal flap is secured in place by

interproximal interrupted sutures and the use of periodontal dressing is optional. Clinical healing is usually complete at six to eight weeks after the surgical procedure, with incremental remodel of soft tissue continuing for up to six to 12 months.

Conclusions

Clinical crown lengthening in the anterior segment of the dentition requires a more elaborate and sophisticated diagnostic process, and treatment modality selection than clinical crown lengthening in the posterior segment because the type of therapy chosen by the clinician will have esthetic ramifications that are mostly irreversible. The execution of the various treatment modalities of crown lengthening in the esthetic zone also require a full understanding of wound healing and particular attention to detail so that a gingival scaffold that is naturally appearing can be developed.

Periodontal surgical therapy is useful in effectively achieving clinical crown lengthening for multiple contiguous teeth in the esthetic zone. But attention to details in the execution of the surgical procedure is crucial in developing a new gingival line that is symmetric, scalloped, and that allows for the execution of prosthetic treatment that enhances the maintenance of periodontal health and that fulfills restorative esthetic requirements. Allowing for adequate healing time after the surgical procedure is very important in the final esthetics of the case.

Forced tooth eruption via rapid orthodontic extrusion is the treatment of choice for the isolated tooth requiring clinical crown lengthening in the esthetic zone, as it leads to the exposure of more tooth structure while maintaining the position of the gingival line and the alveolar bone. Localized periodontal surgical procedures may be necessary to refine esthetics following forced tooth eruption. Restoration of orthodontically extruded teeth may be challenging with regard to developing an emergence profile that matches the one of the same tooth in the adjacent quadrant.

Periodontal surgical therapy is also the therapy of choice in treating cases of excessive gingival display caused by altered passive eruption. It is crucial for the clinician to make an appropriate diagnosis for cases of altered passive eruption, as the etiology of excessive gingival display may be other than altered passive eruption and therefore required other modalities of therapy. In executing the surgical procedures in cases of altered passive eruption, it is recommended a palatal flap and removal of interproximal tissue not be performed in conjunction with the buccal flap to minimize chances of creating loss of interdental papillae.

Finally, when facing the need for clinical crown lengthening in the esthetic zone, the clinician may be tempted to select the gingivectomy technique as the therapeutic approach because of its apparent ease of execution. The gingivectomy technique is usually inadequate to achieve clinical crown lengthening because it does not provide access to the alveolar bone. By and large, clinical crown lengthening procedures require osseous recontouring and should be combined with gingival flaps. As previously suggested, gingivectomies can only be used in achieving clinical crown lengthening in cases were horizontal bone loss and/or excessive soft tissue depth are also present. ■■■■

REFERENCES

1. Glossary of periodontal terms, the American Academy of Periodontology. 4th ed. Chicago, 2001.
2. Cohen DW, Current approaches in periodontology. *J Periodontol* 35:5-18, 1964.
3. Gargiulo AW, Wentz FM, Orban B, Dimensions and relations of the dentogingival junction in humans. *J Periodontol* 32:261-7, 1961.
4. Hausmann E, Allen K, Clerehugh V, What alveolar crest level on a bite-wing radiograph represents bone loss? *J Periodontol* 62:570-2, 1991.
5. Källestål C, Matsson L, Criteria for assessment of interproximal bone loss on bite-wing radiographs in adolescents. *J Clin Periodontol* 16:300-4, 1989.
6. Regan JE, Mitchell DF, Roentgenographic and dissection measurements of alveolar crest height. *J Am Dent Assoc* 66:356-9, 1962.
7. Kois J, The restorative-periodontal interface: biological parameters. *Periodontology 2000*, 11:29-38, 1996.
8. Gunay H, Seeger A, et al, Placement of the preparation line and periodontal health- a prospective two-year clinical study. *Int J Periodontics Restorative Dent* 20:171-81, 2000.
9. Schroeder HE, Listgarten MA, Fine structure of the developing epithelial attachment of human teeth. *Monogr Dev Biol* 2:1-134, 1971.
10. Holmes JR, Sulik WD, et al, Marginal fit of castable ceramic crown. *J Prosthet Dent* 67:594-9, 1992.
11. Chiche GJ, Pinault A, Esthetics of anterior fixed prosthetics. Chicago, Quintessence, 1994.
12. Fradeani M, Esthetic rehabilitation in fixed prosthodontics. Volume I- Esthetic analysis: A systematic approach to prosthetic treatment. Chicago, Quintessence, 2004.
13. Garber DA, Salama MA, The aesthetic smile: diagnosis and treatment. *Periodontology 2000* 11:18-28, 1996.
14. Kokich VO Jr., Kiyak HA, Shapiro PA, Comparing the perception of dentists and lay people to altered dental esthetics. *J Esthet Dent* 11:311-24, 1999.
15. Friedman N, Periodontal osseous surgery: Osteoplasty and ostectomy. *J Periodontol* 26:257-63, 1955.
16. Eissman HF, Radke RA, Postendodontic restoration. In: Cohen S, Burns RC: Pathways of the Pulp. St Louis, CV Mosby Co., pp 537-75, 1976.
17. Smukler H, Chaibi M, Periodontal and dental considerations in clinical crown extension: A rational basis for treatment. *Int J Periodontics Rest Dent* 17:465-77, 1997.
18. Rosenberg ES, Cho SC, Garber DA, Crown lengthening revisited. *Compend Contin Educ Dent* 20:527-32, 1999.
19. Pontoriero R, Carnevale G, Surgical crown lengthening: A 12-month clinical wound healing study. *J Periodontol* 72:841-8, 2001.
20. Ingber JS, Forced eruption: Part II. A method for treating nonrestorable teeth — periodontal and restorative considerations. *J Periodontol* 47:203-16, 1976.
21. Kozlovsky A, Tal H, Lieberman M, Forced eruption combined with gingival fiberotomy. A technique for clinical crown lengthening. *J Clin Periodontol* 15:534-8, 1988.
22. Pontoriero R, Celenza F Jr., et al, Rapid extrusion with fiber resection: A combined orthodontic-periodontic treatment modality. *Int J Periodontics Restorative Dent* 7:30-43, 1987.
23. Simon JH, Lythgoe JB, Torabinejad M, Clinical and histologic evaluation of extruded endodontically treated teeth in dogs. *Oral Surg Oral Med Oral Pathol* 50:361-71, 1980.
24. Edwards JG, A long-term prospective evaluation of the circumferential supracrestal fiberotomy in alleviating orthodontic relapse. *Am J Orthod Dentofacial Orthop* 93:380-7, 1988.
25. Rosenblatt A, Simon Z, Lip repositioning for reduction of excessive gingival display: A clinical report. *Int J Periodontics Restorative Dent* 26:433-7, 2006.

TO REQUEST A PRINTED COPY OF THIS ARTICLE, PLEASE CONTACT Paulo M. Camargo, DDS, MS, University of California, Los Angeles, School of Dentistry, Periodontics CHS 63048, 10833 Le Conte Ave., Los Angeles, CA 90095.

CDA JOURNAL, VOL 35, Nº7

Etiology and Management of Whitening-induced Tooth Hypersensitivity

EDMOND R. HEWLETT, DDS

ABSTRACT Tooth hypersensitivity has long been, and continues to be, the most commonly reported adverse effect of vital tooth whitening with peroxide gels. The complex etiology of whitening-induced tooth hypersensitivity has been a major obstacle in developing a definitive strategy for its prevention. This article reviews the multiple etiologic factors implicated in whitening-induced tooth hypersensitivity and the evidence for efficacy of various strategies for its management.

AUTHOR

Edmond R. Hewlett, DDS, is an associate professor, restorative dentistry, University of California, Los Angeles, School of Dentistry. He has maintained a private practice in restorative and prosthetic dentistry at the UCLA Faculty Group Dental Practice.

At-home vital tooth bleaching — the dentist-dispensed/dentist-supervised use of a carbamide peroxide gel in a custom-fitted tray to whiten teeth — was first described in 1989.[1] Since that time, an extensive body of evidence validating the safety and efficacy of this procedure has been established.[2] As widespread use of the technique became commonplace, however, reports/descriptions of the side effects of gingival irritation and tooth hypersensitivity became commonplace as well.[3-8] Sensitivity is the most frequently reported side effect for home tray whitening.[9] It will commonly manifest itself as generalized hypersensitivity to cold stimuli, but often also occurs as a spontaneous sharp shooting pain or "zinger" limited to one or a few teeth.[10]

Gingival irritation during tray tooth whitening is typically caused by prolonged contact of the peroxide gel with gingival tissues and can be prevented by proper trimming of the tray such that contact with the gel is limited to hard tooth surfaces.[11] A definitive understanding of the tooth hypersensitivity issue however, has been far more elusive, and, as such remains the most common adverse event associated with whitening of vital teeth.[9,12] Reports and estimates of whitening-induced tooth hypersensitivity incidence range from 0 percent to 100 percent, but are more commonly in the 60 percent range, and the degree of hypersensitivity in these reports ranges from very mild to intolerable.[5,8,13,14,16,17] Results of a clinical trial of a 15 percent CP gel by Jorgensen and Carroll were more specific, concluding that about half of all patients who undergo whitening will experience mild sensitivity; 10 percent will have moderate sensitivity; and 4 percent will have severe sensitivity.[18] Schulte et al. reported that 14 percent of subjects in their clinical trial discontinued treatment due to intolerable sensitivity.[5] Despite the fact that the hypersensitivity is transient (sensitivity levels typically return to normal upon completion of, if not during, the whitening treatment), it continues to render peroxide vital tooth whiten-

ing unavailable to patients who experience severe, intolerable hypersensitivity during the procedure.[8,16,19,20] For other patients experiencing less severe symptoms, their discomfort during whitening may nonetheless adversely effect their compliance with the procedure, and thus produce suboptimal results. Efforts to fully elucidate the etiology of and develop strategies to manage or eliminate this side effect thus continue at robust levels.

Etiology

Current understanding of the etiology of peroxide whitening-induced tooth hypersensitivity is constructed around three fundamental concepts: Brännström's hydrodynamic theory of tooth pain; dentinal fluid outflow caused by osmotic stimuli; and permeation during whitening of peroxides through enamel and dentin and into the pulp. Brännström's well-known theory posits that dentinal fluid expands, contracts, or flows within dentinal tubules under the influence of thermal, evaporative, or osmotic changes and stimulates pressure-sensitive nerve receptors (A-δ fibers) that transmit the stimulus and produce the perception of pain.[21,22] Cold is reportedly the most common stimulus for dentin hypersensitivity.[22,23] While this conceptual construct is widely accepted, it is important to remember that tooth sensitivity during whitening is a multifactorial phenomenon and not exclusively dependent on the use of a whitening product.[12]

An understanding of the chemical entities present during vital tooth whitening is essential in order to consider the potential of each as an etiologic agent in tooth hypersensitivity. Key ingredients in whitening gels are typically carbamide peroxide ($CH_6N_2O_3$) or hydrogen peroxide (H_2O_2), glycerin or propylene glycol as the carrier, carbopol — a water-soluble polymer thickening agent common in household products such as toothpaste, shampoo, and flavorings. A slightly acidic pH improves stability (shelf life) of these products, so small amounts of phosphoric or citric acid are commonly added as well.[24] Carbamide peroxide dissociates in saliva into hydrogen peroxide and urea ($Ca[NH_2]_2$). Urea breaks down into ammonia (NH_3) and carbon dioxide (CO_2). Hydrogen peroxide, considered the active whitening ingredient, penetrates into tooth structure and breaks down into oxygen (O_2) and water (H_2O). The released oxygen oxidizes pigment molecules in enamel and dentin to produce the whitening effect.[24]

PENETRATION OF PEROXIDE

through enamel and dentin and into the pulp during tooth whitening has been reported.

Penetration of peroxide through enamel and dentin and into the pulp during tooth whitening has been reported.[25-27] Within five to 15 minutes after application of whitening gel, peroxide penetrates to the pulp where it irritates nerves and essentially produces a reversible pulpitis.[10,27] This etiology, then, can function independently of any osmotic effects on dentin (discussed later in this article) by whitening products, and may account for the common occurrence of sensitivity in patients with no gingival recession or other sites of exposed dentin.

Amounts of peroxide measured in pulps of extracted teeth after simulated 14-day overnight treatment with 3.5 percent, 6 percent, and 12 percent hydrogen peroxide were microgram quantities, with no differences by peroxide concentration or by four-hour versus seven-hour/night regimens.[28] Inasmuch as milligram amounts of peroxide in the pulp are necessary to inhibit pulpal enzymes, available evidence strongly indicates that peroxide from tooth whitening will, at worst, cause only irreversible pulpal irritation.[29]

Histological features of peroxide-whitened teeth further corroborate the common clinical observation that any whitening-induced pulpal changes are reversible.[30-32] Pulpal irritation evident histologically during treatment typically resolves within two weeks of terminating treatment.[32] Studies of long-term (six-month) treatment of tetracycline-stained teeth with at-home tray whitening similarly do not reveal nonresolving pulpal changes or sensitivity symptoms.[33] Furthermore, sensitivity levels reported for tetracycline-stained teeth during long-term whitening are not greater than those for teeth in normal whitening protocols.[33]

Carbamide peroxide allows for a time-release application of hydrogen peroxide and as such has been suggested as having less potential to produce sensitivity.[10] This necessitates, however, longer tray application times for carbamide peroxide versus hydrogen peroxide home whitening products. Ten percent and 20 percent carbamide peroxide break down to release 3.35 percent and 7 percent hydrogen peroxide, respectively. Carbamide peroxide releases 50 percent of its hydrogen peroxide in the first two to four hours of tray application, and the remainder over next two to six hours.[34] Instructions for carbamide peroxide products thus commonly recommend the options of applying the gel in

the tray for two hours during the day or overnight while asleep. While several studies report no significant difference in sensitivity when using 16 percent versus 10 percent carbamide peroxide, these same studies acknowledge a trend toward higher incidence of sensitivity with higher concentrations of carbamide peroxide, and others demonstrate a correlation between sensitivity levels and carbamide peroxide concentration.[20,35,36] It is also noteworthy that while the higher concentration products may shorten overall treatment time by a few days, this relationship is not linear (e.g., 20 percent does not whiten twice as fast at 10 percent).[10]

Dentist-dispensed whitening gels containing 5 percent to 10 percent hydrogen peroxide are marketed with the purported advantage of shorter application time per dose versus carbamide peroxide. Hydrogen peroxide releases all of its oxygen in 30 to 60 minutes of tray application, hence the shorter application times in instructions for use for hydrogen peroxide-containing products.[37] This rapid perfusion of peroxide into the pulp, however, is cited as producing higher sensitivity levels than an equivalent dose of carbamide peroxide.[10]

The aforementioned effects of peroxides on teeth would also account for sensitivity observed with over-the-counter whitening products, which typically contain 5 percent to 6 percent hydrogen peroxide.[38,39] Like dentist-dispensed gels containing hydrogen peroxide, OTC adhesive whitening strips have comparable whitening efficacy with less contact time compared to 10 percent carbamide peroxide in a custom tray.[40] Greater sensitivity has been reported with strips containing higher versus lower concentrations of hydrogen peroxide despite the shorter application time for the former.[41] Betke et al. also reported dentin desiccation by an OTC paint-on whitener containing ethanol but no glycerin.[42]

The actual whitening process, oxidation of organic pigments, may contribute to sensitivity via dehydration. It has been hypothesized that some of the apparent whitening effect perceived immediately upon completion of treatment is due to saturation of the tooth with oxygen altering the refractive index of enamel and dehydration of the tooth from the oxidative process.[24,43] As residual oxygen dissipates over the two weeks following completion of treatment, the actual lightened shade becomes apparent.[44] Rehydration during this period, in addition to restoring the normal optical properties of the teeth and contributing to stabilization of the lightened shade, likely facilitates the re-establishment of osmotic equilibrium in the teeth and resolution of hypersensitivity.

THE ACTUAL WHITENING process, oxidation of organic pigments, may contribute to sensitivity via dehydration.

Numerous studies investigating the efficacy of at-home whitening report sensitivity among subjects in placebo groups ranging from 20 percent to 35 percent, suggesting that peroxide is not the sole etiologic agent.[20,45,46] Placebo formulations typically consist of the whitening gel minus any peroxides. Gel composition and tray fit have thus also been implicated and investigated as possible contributors to whitening-induced sensitivity.

The potential of whitening gel ingredients to act as osmotic stimuli on dentin has been extensively studied. While carbopol is a benign substance in this regard, glycerin — also a common ingredient in many whitening gels — is a desiccant that can cause pain via dentinal fluid outflow.[18] Because of its anhydrous nature and potential for tooth dehydration, glycerin was implicated as the causative agent in whitening-induced tooth sensitivity. Several manufacturers have thus replaced glycerin with water-based solutions or formulations with added water, or have substituted propylene glycol for glycerin as gel base inasmuch as this may also reduce sensitivity.[20,47,48] These strategies were initially based on a presumed desiccating effect of glycerin on dentin, but this effect was eventually directly demonstrated in vitro.[42]

Tray pressure as a cause of sensitivity has been suggested by findings such as those by Leonard et al. who reported that 20 percent of participants in a clinical trial experienced sensitivity when wearing the tray alone.[20] A tightly adapted tray can theoretically apply active orthodontic forces effecting small degrees of tooth movement and thus giving rise to mild levels of sensitivity. Trays are less rigid now versus early years of tray whitening and are less likely to exert orthodontic forces on teeth.[15] Additionally, a tray design using reservoirs on the labial surfaces was presumed to both reduce the tray-induced sensitivity via a relaxed fit and to improve efficacy by holding a larger volume of whitening gel against each tooth. Reported evidence of these effects by reservoirs is equivocal, however, with several studies finding no difference in sensitivity or color change when comparing trays with and without reservoirs.[20,49]

Crim reported that a carbamide

CDA JOURNAL, VOL 35, Nº7

peroxide whitening gel adversely affected the marginal seal of class V restorations at the cementoenamel junction in vitro.[50] Evidence of increased microleakage or accelerated failure of restorations subjected to at-home whitening is otherwise absent in the literature as well as anecdotally. Available clinical data similarly do not report differences in whitening-induced hypersensitivity between restored and unrestored teeth. Teeth with carious lesions and failing/leaking restorations are nonetheless at high risk for whitening-induced hypersensitivity as relatively large volumes of gel can directly contact deep dentin and produce sensitivity via the mechanisms described previously. It is thus prudent and widely recommended that such sites be restored at least on an interim basis, e.g., with glass ionomer, prior to initiating whitening procedures.[51,52]

Management

Just as the understanding of mechanisms at work in whitening-induced hypersensitivity remains incomplete, no definitive strategy for prevention of its occurrence has emerged. Strategies for management of hypersensitivity associated with tooth whitening such as they currently exist include those conducted prior to whitening (reduction/elimination of pre-existing hypersensitivity or reduction of hypersensitivity risk) and in conjunction with whitening ("desensitizing" additives to whitening gels, and adjunctive desensitizer products for home use). Clinicians typically utilize a product-based approach as a first-line treatment for hypersensitivity, but evidence suggests that pretreatment assessment and increased focus on preventive strategies are equally, if not more, effective.

Pre-existing hypersensitivity and a whitening regimen of more than one application of product per day are the best predictors of moderate-to-severe hypersensitivity during whitening.[11,13,15,51] Gingival recession, on the other hand, is at best a contributing factor to pre-existing sensitivity, but not a predictor — most studies have found no association between gingival recession and tooth whitening.[15,18] Leonard et al. ruled out patient age and gender as predictors of sensitivity during whitening, but a subsequent study by Matis et al. reported higher incidence of sensitivity with females and patients under age 40 versus males and patients over 40.[11,49]

GINGIVAL RECESSION, on the other hand, is at best a contributing factor to pre-existing sensitivity, but not a predictor.

Prevalence of pre-existing dentinal hypersensitivity has been reported to vary from 4 percent to 57 percent in the general adult population, and from 60 percent to 98 percent in periodontal patients.[23,53-56] It has been suggested this broad range reflects the differences in the populations studied and the investigation methods, and may also reflect structural differences — more and larger tubule openings — in sensitive versus nonsensitive dentin.[57,58] It is nonetheless clear that a careful screening for hypersensitivity prior to home whitening procedures is appropriate.

Several reports suggest that dentin hypersensitivity is probably underdiagnosed and undertreated.[47] Orchardson, in an excellent general review of dentin hypersensitivity, pointed out that strategies for its prevention are perhaps underutilized.[57,59] Specifically, the role of agents that increase dentin surface permeability (dietary and gastric sources of acid, abrasive dentifrices) must not be overlooked. Patient screening should include queries that identify potential etiologic agents in the diet (acidic foods/beverages such as carbonated soft drinks — especially colas — sports drinks, fruits and fruit juices, white wine, and yogurt); digestive tract (gastric reflux, regurgitation); and oral hygiene habits (dentifrice type, toothbrush type, toothbrushing technique). These factors can be effectively managed by increasing patients' awareness of their role in tooth hypersensitivity and thus motivating patients toward modifications in diet and oral hygiene, and in seeking medical management of gastrointestinal disorders. Leonard et al. also recommended asking patients before whitening if their teeth are sensitive to hot and cold, or after a prophy, and use gentle blast of air to assess.[11]

Acid erosion and abrasion can reportedly combine to potentiate each other's individual effects as etiologic agents in dentin hypersensitivity.[60] It has therefore been recommended that patients delay toothbrushing until at least two hours after ingesting acidic foods or drinks to reduce any combined harmful effects on dentin permeability.[56,57,59,60] The recommendation presumes remineralization of the acid-softened dentin by salivary calcium, phosphate, and fluoride over the two hours, thus restoring the dentin's abrasion resistance. Studies attempting to validate this recommendation, however, have had varied results, including no improvement in abrasion resistance after one to two hours salivary remineralization.[61,62] Rinsing for one minute with a 2,000 ppm sodium fluoride solu-

tion immediately before brushing was shown to significantly reduce abrasion of acid-eroded dentin in vitro.[63] Use of a fluoridated mouthrinse in lieu of brushing after ingesting acidic food or drinks to augment the saliva's remineralization capacity thus appears to be prudent.

A common recommendation for treating whitening-induced tooth hypersensitivity is to reduce the frequency or duration of whitening applications.[8,16] This approach can render the whitening procedure tolerable for some patients who would otherwise find the procedure too uncomfortable, but it does lengthen total treatment time significantly.

Products used to manage dentin hypersensitivity fall into two broad categories: agents that reduce dentin permeability either by occluding tubule openings on exposed dentin surfaces or by hypermineralization, and those that block nerve conduction.

Tooth pain from dentin hypersensitivity is caused by depolarization, then repolarization resulting in activity of dentinal sensory nerves. Potassium nitrate acts by preventing nerve repolarization after initial depolarization, reducing nerve excitability and the ability of the nerve to transmit pain.[64,65] Like hydrogen peroxide, potassium nitrate also rapidly (within minutes) filters through enamel and dentin and in to the pulp.[63]

Over-the-counter "desensitizing" dentifrices containing 5 percent potassium nitrate have long been available and have been extensively studied. Several clinical trials have reported the efficacy of potassium nitrate as a dentifrice additive.[67-69] Brushing with a potassium nitrate toothpaste was shown to reduce sensitivity in two weeks.[67] Toothbrushing with potassium nitrate dentifrice must be done twice a day as part of an ongoing brushing routine in order to produce a desensitizing effect.[23] Overall, however, evidence addressing the efficacy of potassium nitrate as a desensitizer is equivocal. A 2001 meta-analysis of four randomized clinical trials failed to produce conclusive evidence of significant efficacy for potassium nitrate in reducing cervical hypersensitivity.[67]

It is also noteworthy that most research into the desensitizing efficacy of potassium nitrate has been examined with respect to its use as a dentifrice additive to desensitize cervical dentin. The degree to which it reduces sensitivity during tooth whitening when used as an additive to whitening gels remains in question.[9,26] Tam examined the efficacy of 3 percent potassium nitrate and 0.11 fluoride ion wt/vol in reducing sensitivity when added to a 10 percent carbamide peroxide whitening gel.[16] The additives were reported to significantly reduce, but not eliminate sensitivity. The study also did not attempt to differentiate between effects of one versus the other additive.

PREBRUSHING WITH a potassium nitrate dentifrice for two weeks was reported to reduce sensitivity during whitening.

Adequate evidence exists, nonetheless, to state that potassium nitrate-containing dentifrices and desensitizer gels are indicated for management of mild of moderate hypersensitivity.[56] It is non-invasive, treats multiple teeth simultaneously, and inexpensive compared to in-office treatment such as sealing sensitive areas with adhesive resin.[47]

The efficacy of a dentist-dispensed desensitizer gel containing 5 percent potassium nitrate + 1,000-ppm fluoride ion for use in bleaching tray has also been investigated.[12,71] Haywood et al. concluded that 10 to 30 minutes wearing time of the gel in the tray before or after whitening may reduce sensitivity in more than 90 percent of patients and make whitening tolerable.[71] Leonard et al. assessed efficacy of the gel to prevent or decrease sensitivity compared to placebo in an at-risk population, i.e., patients reporting pre-existing sensitivity and risk factors.[12] They reported efficacy — 41 percent in the treatment group had at least one day of sensitivity versus 78 percent in the placebo group. The gel can also be used as needed during the day or worn in the tray on alternating nights when an overnight whitening regimen is used.[10]

Prebrushing with a potassium nitrate dentifrice for two weeks was reported to reduce sensitivity during whitening, and the efficacy of an OTC potassium nitrate dentifrice worn in a tray has been investigated as well.[72] Tray application for several hours/day for one week was shown to provide relief from tooth sensitivity, and 10 to 30 minutes of tray application immediately prior to a dental prophylaxis reduced discomfort during and after the procedure.[51,73] However, some toothpaste ingredients such as sodium lauryl sulfate (a foaming ingredient) or flavorings may give rise to gingival irritations (apthous ulcers) when applied in a tray for extended periods.[10]

Haywood nonetheless recommended initially using an OTC dentifrice as a tray-applied desensitizer due to its cost-effectiveness and convenience, then switching to a dentist-dispensed desensitizer gel if gingival irritation occurs.[10]

Agents for desensitization via block-

CDA JOURNAL, VOL 35, Nº7

age of patent dentinal tubules include fluoride, oxalate compounds, and derivatives of resin adhesive restorative products. Tubule blockers have been reported to have varying levels of efficacy on general dentin hypersensitivity, and their potential to prevent whitening-induced hypersensitivity is limited to reduction in osmotic stimulation on exposed dentin surfaces. These agents have no effect on peroxide diffusion to the pulp and as such should not be expected to completely eliminate whitening-induced hypersensitivity.

Neutral sodium fluoride works by occlusion of dentinal tubules with fluoride precipitates; calcium fluoride is produced after exposure of dentin to high concentrations of topical fluoride, and fluorapatite is produced after exposure to lower concentrations.[16] Brushing with a fluoride gel for four weeks was shown to reduce cervical hypersensitivity.[74] A single application of a 5 percent sodium fluoride varnish has been shown to reduce cervical dentin hypersensitivity within two weeks.[75]

Anecdotally, the author has observed that brushing twice daily with a 5000 ppm F dentifrice for one week prewhitening reduced discomfort during whitening. Evidence suggested that tubule blockage by fluoride has limited efficacy in treating whitening-induced hypersensitivity, however, since the peroxide molecule is small enough to pass through the interstitial spaces between tubules.[10] Betke et al. demonstrated that a fluoride varnish failed to inhibit dentin dehydration by whitening agents.[28] It was postulated that any calcium-fluoride precipitate formed by the varnish was inadequate inhibit dehydration.

Oxalate salts form a crystalline precipitate of calcium oxalate to occlude dentinal tubules immediately upon application, and thus reduce or prevent fluid movement.[76] Swift described the following categories of these dentist-dispensed products: potassium oxalate (Protect, Butler; Therma-Trol, Premier; Super Seal, Phoenix), ferric oxalate + acp + potassium phosphate (Quell, Pentron); potassium phosphate + potassium carbonate + calcium chloride + strontium chloride (D/Sense 2, Centrix).[47] Efficacy of these products for general management of cervical hypersensitivity has been demonstrated.[77,78] A variant of this product type (Pain-Free, Parkell) contains 3 percent oxalic acid + 5 percent polymethyl methacrylate-co-p-styrenesulfonic acid to produce a resin seal on exposed dentin along with tubule blocking via the oxalate precipitate.[47]

THE NEWEST PRODUCTS aimed at hypersensitivity management are those containing amorphous calcium phosphate as the active ingredient.

Resin-based desensitizing "varnishes" are essentially the hydrophilic resin primer component (2-hydroxyethyl methacrylate, or HEMA) common to many adhesive resin bonding products with the addition of an antibacterial compound. Examples include Gluma Desensitizer (Heraeus Kulzer), originally sold as a dentin primer, an aqueous solution of 35 percent HEMA and 5 percent gluteraldehyde 26; HurriSeal (Beutlich) — 35 percent HEMA + benzalkonium chloride+ NaF; Hemaseal and Cide (Advantage Dental Products) — HEMA + 4 percent chlorhexidine).[26]

Several reports cite the efficacy of this approach: An assessment of several such products by Clinical Research Associates, however, found that while all reduced sensitivity, none provided relief in 100 percent of cases.[79-82] It should be noted that one of the varnishes in this study, an acetone-containing dentin adhesive, produced significant dehydration of the dentin samples during its application despite creating a protective seal against dehydration by whitener products. Limitations of resin varnish desensitization include thin layers subject to eventual loss via abrasion, techniques sensitivity (care must be taken to prevent moisture contamination and prevent pooling of resin into thick layers), limited access to interproximal root surfaces, and expense. Additionally, and as mentioned previously, these products have limited efficacy in reducing whitening-induced sensitivity inasmuch as they do not prevent diffusion of peroxide to the pulp.

The newest products aimed at hypersensitivity management are those containing amorphous calcium phosphate as the active ingredient. ACP forms hydroxyapatite in enamel and increases enamel hardness, hence its primary application as an agent to remineralize carious lesions, as well as reduce susceptibility to their formation. An effective delivery system for ACP has been developed by combining it with casein phosphopeptide, a milk protein derivate. The resultant complex — CPP-ACP, aka Recaldent, stabilizes the ACP such that it provides a reservoir of calcium and phosphate that remain bioavailable in saliva for several hours after application. Topical application of a CPP-ACP-containing paste (Prospec, MI Paste, GC America) has been shown to rapidly reduce dentin hypersensitivity, suggesting its applicability in managing whitening-induced hypersensitivity.[83,84] ACP (without CPP) is now present as

an additive in some whitening products as well.[85] Reports of efficacy in this regard are promising to date, with one clinical trial citing sensitivity remaining at levels similar to baseline.[86]

Summary and Conclusions

Whitening-induced tooth hypersensitivity is a complex, multifactorial phenomenon and as such, continues to defy attempts to develop definitive preventive therapies. The best currently available evidence suggests the following:

- Pretreatment assessment of baseline tooth hypersensitivity is key to the effective management of whitening-induced hypersensitivity. Thorough screening for risk factors (acidic foods, gastric reflux, abrasive dentifrices) facilitates the elimination of these factors and reduction of baseline sensitivity before whitening treatment is initiated.
- Carious lesions and failing/leaking restorations should be addressed prior to whitening treatment. Interim restoration of these sites with a glass ionomer material provides an excellent microleakage-resistant seal to potentially reduce sensitivity during whitening, arrest lesion progression, and stabilize involved teeth until postwhitening shade matching and definitive restoration can be conducted.
- Increased frequency of whitening gel application is associated with higher levels of sensitivity during treatment. Instructions to patients should stress adherence to appropriate protocols for the products being used.
- Carbamide peroxide products tend to produce less sensitivity than those containing hydrogen peroxide, and should be the first choice for patients with significant levels of pre-existing hypersensitivity.
- Topically applied potassium nitrate is an effective method for reducing whitening-induced hypersensitivity. Brushing twice daily with an OTC dentifrice containing potassium nitrate for two weeks prior to whitening can reduce baseline sensitivity and risk of discomfort during whitening. The dentifrice can also be used in the tray for up to 30 minutes before and/or after whitening gel application to manage sensitivity during treatment. Dentist-dispensed gels containing potassium nitrate for tray application have also demonstrated efficacy in sensitivity reduction.
- Products containing amorphous calcium phosphate show promise for management of sensitivity via topical application. Whitening gels containing ACP may also prove to be effective in this regard. ■■■■

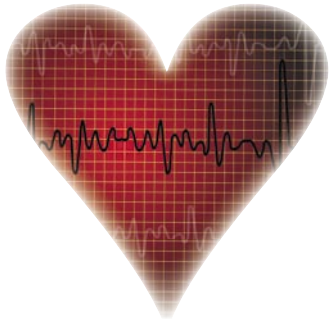
REFERENCES

1. Haywood VB, Heymann HO, Nightguard vital bleaching. *Quintessence Int* 20:173-6, 1989.
2. Li Y, Tooth bleaching using peroxide containing agents: Current status of safety issues. *Compend Contin Educ Dent* 19:783-96, 1998.
3. Christensen G, Christensen R, Home-use bleaching survey-1991. *CRA Newsletter* 15:2, 1991.
4. Reinhardt JW, Eivins SE, et al, A clinical study of nightguard vital bleaching. *Quintessence Int* 24:379-84, 1993.
5. Schulte JR, Morrissette DB, et al, The effects of bleaching application time on the dental pulp. *J Amer Dent Assoc* 125:1330-5, 1994.
6. Gegauff AG, Rosensteil SF, et al, Evaluation of tooth color change from carbamide peroxide gel. *J Am Dent Assoc* 124:26-72, 1993.
7. Haywood VB, Overview and status of mouthguard bleaching. *J Esthet Dent* 3:157-61, 1991.
8. Leonard RH Jr., Efficacy, longevity, side effects, and patient perceptions of nightguard vital bleaching. *Compend Contin Educ Dent* 19:766-81, 1998.
9. Pohjola RM, Browning WD, et al, Sensitivity and tooth whitening agents. *J Esthet Rest Dent* 14:85-91, 2002.
10. Haywood VB, Treating tooth sensitivity during whitening. *Compend Contin Educ Dent* 26(supp 3):11-20, 2005.
11. Leonard RH, Haywood VB, Phillips C, Risk factors for developing tooth sensitivity and gingival irritation associated with nightguard vital bleaching. *Quint Int* 28:527-34,1997.
12. Leonard RH Jr., Smith L, et al, Desensitizing agent efficacy during whitening in an at-risk population. *J Esthet Restor Dent* 16:49-56, 2004.
13. Haywood VB, Leonard RH, et al, Effectiveness, side effects, and long-term status of nightguard vital bleaching. *J Am Dent Assoc* 125:1219-26, 1994.
14. Sterrett J, Price RB, Bankey T, Effects of home bleaching on the tissues of the oral cavity. *J Can Dent Assoc* 61:412-20, 1995.
15. Swift EJ, Tooth sensitivity and whitening. *Compend Contin Educ Dent* 26(supp 3):4-10, 2005.
16. Tam L, Effect of potassium nitrate and fluoride on carbamide peroxide bleaching. *Quintessence Int* 32:766-70, 2001.
17. Haywood VB, Current status of nightguard vital bleaching. *Compend Contin Educ Dent* 21(supp 28):S10-7, 2000.
18. Jorgensen MG, Carroll WB, Incidence of tooth sensitivity after home whitening treatment. *J Am Dent Assoc* 133:1076-82, 2002.
19. Auschill TM, Hellwig E, et al, Efficacy, side effects, and patients' acceptance of different bleaching techniques (OTC, in-office, at-home). *Oper Dent* 30:156-63, 2005.
20. Leonard RH, Garland GE, et al, Safety issues when using a 16 percent carbamide peroxide whitening solution. *J Esthet Restor Dent* 14:358-67, 2002.
21. Brännström M, Astrom A, The hydrodynamics of the dentine; its possible relationship to dentinal pain. *Int Dent J* 22:219-27, 1972.
22. Walters PA, Dentinal Hypersensitivity: A review. *J Contemp Dent Pract* 6:107-17, 2005.
23. Addy M, Dentine hypersensitivity: new perspectives on an old problem. *Int J Dent* 52:367-375, 2002.
24. Albers H, At-home bleaching. Adept Report (vol. 6) Santa Rosa: Adept Institute, 2000.
25. Hanks CT, Fat JC, et al, Cytotoxicity and dentin permeability of carbamide peroxide and hydrogen peroxide vital bleaching materials, in vitro. *J Dent Res* 72:931-8, 1993.
26. Thitinanthapan W, Satamanont P, Vongsavan N, In vitro penetration of the pulp chamber by three brands of carbamide peroxide. *J Esthet Dent* 11:259-64, 1999.
27. Cooper JS, Bokmeyer TJ, Bowles WH, Penetration of the pulp camber by carbamide peroxide bleaching agents. *J Endod* 18:315-7, 1992.
28. Pugh G Jr., Zaidel L, et al, High levels of hydrogen peroxide in overnight tooth-whitening formulas: Effects on enamel and pulp. *J Esthet Restor Dent* 17:40-7, 2005.
29. Bowles WH, Ugwuneri Z, Pulp chamber penetration by hydrogen peroxide following vital bleaching procedures. *J Endod* 13:375-7, 1987.
30. Cohen SC, Human pulpal response to bleaching procedures on vital teeth. *J Endod* 5:134-8, 1979.
31. Robertson WD, Melfi RC, Pulpal response to vital bleaching procedure. *J Endod* 6:645-9, 1980.
32. Fugaro JO, Nordahl I, et al, Pulp reaction to vital bleaching *Oper Dent* 29:363-8, 2004.
33. Leonard RH Jr., Haywood VB, et al, Nightguard vital bleaching of tetracycline-stained teeth: 90 months post-treatment. *J Esthet Restor Dent* 15:142-53, 2003.
34. Matis BA, Gaiao U, et al, In vivo degradation of bleaching gel used in whitening teeth. *J Am Dent Assoc* 130:227-35, 1999.
35. Matis BA, Mousa HN, et al, Clinical evaluations of bleaching agents of different concentrations. *Quintessence Int* 31:303-10, 2000.
36. Kihn PW, Barnes DM, et al, A clinical evaluation of 10 percent versus 15 percent carbamide peroxide tooth-whitening agent. *J Amer Dent Assoc* 131:1478-84, 2000.
37. Al-Qunaian TA, Matis, BA, Cochran MA, In vivo kinetics of bleaching gel with 3 percent hydrogen peroxide within the first hour. *Oper Dent* 28:236-41, 2003.
38. Matis BA, Cochran MA, et al, A clinical evaluation of bleaching using whitening wraps and strips. *Oper Dent* 30:558-92, 2005.

39. Nathoo S, Santana E, et al, Comparative seven-day evaluation of two tooth-whitening products. *Compend Contin Educ Dent* 22:599-606, 2001.
40. Gerlach RW, Gibb RD, Sagel PA, A randomized clinical trial comparing a novel 5.3 percent hydrogen peroxide bleaching strip to 10 percent, 15 percent, and 20 percent carbamide peroxide tray-based bleaching systems. *Compend Contin Educ Dent Supplement* 21:S22-8, 2000.
41. Gerlach RW, Sagel PA, Vital bleaching with a thin peroxide gel: The safety and efficacy of a professional strength hydrogen peroxide whitening strip. [Published erratum appears in J Am Dent Assoc 135:156, 2004]. *J Am Dent Assoc* 135:98-100, 2004.
42. Betke H, Kahler E, et al, Influence of bleaching agents and desensitizing varnishes on the water content of dentin. *Oper Dent* 31:536-42, 2006.
43. Zantner C, Derdilopoulou F, et al, Randomized clinical trial on the efficacy of a new bleaching lacquer for self-application. *Oper Dent* 31:308-31, 2006.
44. Greenwall L, Bleaching techniques in restorative dentistry. London, Martin Dunitz, 2001.
45. Matis BA, Cochran MA, et al, The efficacy and safety of a 10 percent carbamide peroxide bleaching gel. *Quintessence Int* 29:555-63, 1998.
46. Leonard RH Jr., Bentley C, et al, Nightguard vital bleaching: A long-term study on efficacy, shade retention. Side effects, and patients' perceptions. *J Esthet Restor Dent* 13:357-69, 2001.
47. Swift EJ, Causes, prevention, and treatment of dentin hypersensitivity. *Compen Contin Educ Dent* 25:95-109, 2004.
48. Gerlach RW, Zhou X, Comparative clinical efficacy of two professional bleaching systems. *Compend Contin Educ Dent* 23(special issue):35-41, 2002.
49. Matis BA, Hamdan YS, et al, A clinical evaluation of a bleaching agent used with and without reservoirs. *Oper Dent* 27:5-11, 2002.
50. Crim GA, Postoperative bleaching effect on microleakage. *Am J Dent* 5:190-12, 1992.
51. Haywood VB, Dentine hypersensitivity: Bleaching and restorative considerations for successful management. *Int Dent J* 52(supp1):376-84, 2002.
52. Nathanson D, Vital tooth bleaching: Sensitivity and pulpal considerations. *J Amer Dent Assoc* 128(suppl):41S-4S, 1997.
53. Rees JS, Addy M, A cross-sectional study of dentine hypersensitivity. *J Clin Periodontol* 29:997-1003, 2002.
54. Chabanski MB, Gillam DG, et al, Prevalence of cervical dentine hypersensitivity in a population of patients referred to a specialist periodontology department. *J Clin Periodontol* 23:989-92, 1996.
55. Taani S, Awartani F, Clinical evaluation of cervical dentin sensitivity in patients attending general dental clinics and periodontal specialty clinics. *J Clin Periodontol* 29:118-22, 2002.
56. Taani S, Awartani F, Clinical evaluation of cervical dentin sensitivity in patients attending general dental clinics and periodontal specialty clinics. *J Clin Periodontol* 29:118-22, 2002.
57. Orchardson R, Managing dentin hypersensitivity. *J Am Dent Assoc* 137:990-8, 2006.
58. Absi EG, Addy M, Adams D, Dentine hypersensitivity. A study of the patency of dentinal tubules in sensitive and non-sensitive cervical dentin. *J Clin Periodontol* 14:280-4, 1987.
59. Canadian Advisory Board on Dentin Hypersensitivity. Consensus-based recommendations on for the diagnosis and management of dentin hypersensitivity. *J Can Dent Assoc* 69:221-6, 2003.
60. Addy M, Hunter ML, Can tooth brushing damage your health? Effects on oral and dental tissues. *Int J Dent* 53(supp 3):177-86, 2003.
61. Attin T, Buchalla W, Putz B, In vitro evaluation of different remineralization periods in improving the resistance of previously eroded bovine dentine against tooth-brushing abrasion. *Arch Oral Biol* 46:871-4, 2001.
62. Hara AT, Turssi CP, et al, Abrasive wear on eroded root dentine after different periods of exposure to saliva in situ. *Eur J Oral Sci* 111:423-7, 2003.
63. Attin T, Zirkel C, Hellwig E, Brushing abrasion of eroded dentin after application of sodium fluoride solutions. *Caries Res* 32:344-50.
64. Markowitz K, Kim S, Hypersensitive teeth. Experimental studies of dentinal desensitizing agents. *Dent Clin North Am* 34:491-501, 1990.
65. Touyz LZG, Stern J, Hypersensitive dentinal pain attenuation with potassium nitrate. *Gen Dent* 47:42-5, 1999.
66. Hodosh M, A superior desensitizer — potassium nitrate. *J Am Dent Assoc* 88:831-2, 1974.
67. Silverman G, Berman E, et al, Assessing the efficacy of three dentifrices in the treatment of dentinal hypersensitivity. *J Am Dent Assoc* 127:191-201, 1996.
68. Orchardson R, Gillam DG, The efficacy of potassium salts as agents for treating dentin hypersensitivity. *J Orofac Pain* 14:9-19, 2000.
69. Schiff T, Bonta Y, et al, Desensitizing efficacy of a new dentifrice containing 5.0 percent potassium nitrate and 04.45 percent stannous fluoride. *Am J Dent* 3:111-5, 2000.
70. Schiff T, Bonta Y, et al, Desensitizing efficacy of a new dentifrice containing 5.0 percent potassium nitrate and 04.45 percent stannous fluoride. *Am J Dent* 3:111-5, 2000.
71. Haywood VB, Caughman WF, et al, Tray delivery of potassium nitrate-fluoride to reduce bleaching sensitivity. *Quintessence Int* 32:105-9, 2001.
72. Haywood VB, Cordero R, et al, Brushing with a potassium nitrate dentifrice to reduce bleaching sensitivity. *J Clin Dent* 16:17-22, 2005.
73. Jerome CE, Acute care for unusual cases of dentinal hypersensitivity. *Quint Int* 26:715-6, 1995.
74. Jerome CE, Acute care for unusual cases of dentinal hypersensitivity. *Quint Int* 26:715-6, 1995.
75. Ritter AV, de L Dias W, et al, Treating cervical dentin hypersensitivity with fluoride varnish. A randomized clinical study. *J Amer Dent Assoc* 137: 1013-20, 2006.
76. Gillam DG, Mordan AD, et al, The effects of oxalate-containing products on the exposed dentin surface: An SEM investigation. *J Oral Rehab* 28:1037-44, 2001.
77. Muzzin KB, Johnson R, Effects of potassium oxalate on dentin hypersensitivity in vivo. *J Periodontol* 60:151-8, 1989.
78. Gillam DG, Coventry JF, et al, Comparison of two desensitizing agents for the treatment of cervical dentine hypersensitivity. *Endod Dent Traumatol* 13:36-9, 1997.
79. Swift EJ Jr., May KN Jr., Mitchell S, Clinical evaluation of prime & bond 2.1 for treating cervical dentin hypersensitivity. *Am J Dent* 14:13-6, 2001.
80. Dondi dall'Orologio G, Lorenzi R, et al, Dentin desensitizing effects of gluma alternate, health-dent desensitizer and scotchbond multi-purpose. *Am J Dent* 12:103-6, 1999.
81. Prati C, Cervellati F, et al, Treatment of cervical dentin hypersensitivity with resin adhesives: Four-week evaluation. *Am J Dent* 14:378-82, 2001.
82. Clinical Research Associates. Desensitizer use with restorative procedures. *CRA newsletter* 26(8):1-3, 2002.
83. Geiger S, Matalon S, et al, The clinical effect of amorphous calcium phosphate on root surface hypersensitivity. *Oper Dent*. 28:496-500. 2003.
84. Yates R, Owens J, et al, A split-mouth placebo-controlled study to determine the effects of amorphous calcium phosphate in the treatment of dentine hypersensitivity. *J Clin Periodontol* 25:687-92, 1998.
85. Giniger M, Macdonald J, et al, The clinical performance of a professionally dispensed bleaching gel with added amorphous calcium phosphate. *J Am Dent Assoc* 136:383-92, 2005.
86. Giniger M, Spaid M, et al, A 180-day clinical investigation of the tooth whitening efficacy of a bleaching gel with added amorphous calcium phosphate. *J Clin Dent* 16:11-6, 2005.

TO REQUEST A PRINTED COPY OF THIS ARTICLE, PLEASE CONTACT
Edmond R. Hewlett, DDS, University of California, Los Angeles, School of Dentistry, 10833 Le Conte Ave., Box 951668, Los Angeles, CA 90095.

CDA JOURNAL, VOL 35, Nº7



Perspectives on the 2007 AHA Endocarditis Prevention Guidelines

THOMAS J. PALLASCH, DDS, MS

ABSTRACT From 2005 to 2007, the American Heart Association convened a consensus panel of experts to revisit the guidelines for the premedication of patients with cardiac defects prior to dental treatment. Presented in this article is a summary of the guidelines as well as commentary on the process.

AUTHOR

Thomas J. Pallasch, DDS, MS, is emeritus professor of dentistry, University of Southern California School of Dentistry, Los Angeles.

DISCLOSURE

The author was a member of the Writing Group for the 2007 Prevention of Infective Endocarditis Guidelines from the American Heart Association. The opinions stated herein are not necessarily those of the American Heart Association Perspectives on the 2007 AHA Endocarditis Prevention Guidelines.

This year is the 98th anniversary of the contention that "previously sclerosed endocarditis" was, in most cases, due to mouth microorganisms.[1] It also is approximately 80 years since dental treatment procedures were considered a primary cause of infective endocarditis, even as data increasingly accumulated that random bacteremias associated with daily living activities (brushing, flossing, mastication) were similar in magnitude and incidence to those associated with dental treatment. Most failed to realize that dental treatment occurred only a few times a year, while the bacteremias associated with daily living were more or less continuous.[2]

These early conclusions were severely biased as they occurred during the heyday of the Focal Theory of Infection, which attributed essentially every disease that was untreatable or of unknown etiology (most of them), including arthritis to gastrointestinal upset and stupidity to bacteria originating in the oral cavity or the tonsils.[3,4] Curiously, virtually all foci of infection were surgically accessible. This era is presently being revisited, but more about that later. The Focal Infection Theory clearly brought to light the apparent necessity of medicine to find a reason for everything, including blaming dentistry and the oral flora for endocarditis and just about everything else. Some find it very difficult to say, "I don't know."

Beginning around the early 1980s, a few bold individuals began to contest this conventional wisdom and suggest that dental treatment was not responsible for many, or even any, of these infective endocarditis (IE) cases.[5-27] Some became weary of being accused of seriously injuring or even killing dental patients by physicians who blithely ignored their own record of hundreds of thousands of nosocomial (hospital-acquired) deaths per year due to mistakes and multiple antibiotic resistant microorganisms.

Little attention was paid to the incuba-

CDA JOURNAL, VOL 35, Nº7

TABLE 1

Recommendations of the 2007 AHA Endocarditis Prevention Guidelines[27]

Dental Procedures for Which Endocarditis Prophylaxis is Recommended
All dental procedures that involve manipulation of gingival tissue or the periapical region of the teeth or perforation of the oral mucosa

Cardiac Conditions Associated With the Highest Risk of Adverse Outcomes From Endocarditis for Which Prophylaxis With Dental Procedures Is Recommended:

- Prosthetic heart valve
- Previous endocarditis
- Cardiac transplant recipients who develop cardiac valvulopathy
- Congenital heart disease (only for conditions listed below and no other CHD)
- Unrepaired cyanotic congenital heart disease (CHD), including palliative stents and conduits
- Completely repaired congenital heart defect with prosthetic material or device, whether placed by surgery or by catheter intervention, during the first six months after the procedure
- Repaired CHD with residual defects at the site or adjacent to the site of a prosthetic patch or prosthetic device (which inhibit endothelialization)

Oral Prophylaxis Regimens Prior to a Dental Procedure in the Above Situations
Single dose 30 minutes to 60 minutes before procedure

Situation	Agent	Adults	Children
Oral	amoxicillin	2 grams	50 mg/kg
Allergic to penicillins	clindamycin or cephalexin[1] or azithromycin or clarithromycin	600 mg 2 grams 500 mg	20 mg/kg 50 mg/kg 15 mg/kg

* Cephalosporins should not be used in an individual with a history of anaphylaxis, angioedema, or urticaria with penicillins.

tion period (the time from the onset of the bacteremia to the first signs and symptoms) of viridans group streptococcal (VGS) endocarditis (usually seven to 14 days), or that the alleged causative bacteremia could more easily have come from daily living activities before or after the dental treatment. It was impossible to tell which it was, but that was considered irrelevant. The author has been involved for more than 35 years in malpractice litigation involving endocarditis causation (more than 300 cases) with only three occurring within this incubation period (1 percent). It was similarly impossible in these few situations to determine causality from dental treatment or daily living bacteremias.

In all these cases, without exception, the question was asked in the hospital usually of a relative: When was their last dental treatment? A positive response of "yesterday" up to "nine months ago" was inevitably followed by: "That did it!" Two hundred and seventy days between dental treatment and the onset of symptoms may be the world record. Recently, a cardiologist stated he could think of nothing else in the six months after the dental treatment that could have caused the VGS endocarditis.

With the advent of the 2007 American Heart Association Prevention of Infective Endocarditis guidelines, it is hoped that much or all of this thinking will change.[27] However one must recall the observation of a noted scientist that a new idea is accepted only when all its critics are dead. Unfortunately, the proponents of the idea will also likely have passed on. In the words of Schopenhauer, "All truth passes through three stages. First it is ridiculed. Second it is violently opposed. Third it is accepted as being self-evident."

The major changes in the prevention of endocarditis in the 2007 AHA guidelines are: 1) only an extremely small number of cases of IE might be prevented by antibiotic prophylaxis for dental procedures, even if such prophylaxis were 100 percent effective; 2) IE prophylaxis for dental procedures should be recommended only for patients with underlying cardiac conditions associated with the highest risk of adverse outcome from IE; 3) for patients with these underlying conditions, prophylaxis is recommended for all dental procedures that involve manipulation of the gingival tissue or the periapical region of the teeth or perforation of the oral mucosa; and 4) prophylaxis is not recommended based solely on an increased lifetime risk of acquisition of infective endocarditis.[27] TABLE 1 places these indications and antibiotic doses in a single chart.

The most fundamental conceptual change since the 1997 guidelines is that the 2007 recommendations are based not solely on the lifetime risk of acquisition of IE but rather on the highest risk of adverse outcomes from IE. It is not the risk of contracting IE, but rather the seriousness of outcome of the disease.

The AHA 2007 guidelines also list the primary reasons for this revision of IE prophylaxis guidelines: 1) IE is much more likely to result from frequent exposure to random bacteremias associated with daily activities than from bacteremia caused by a dental, GI tract, or GU tract procedure; 2) prophylaxis may prevent an exceedingly small number of cases of IE, if any, in individuals who undergo a dental, GI tract, or GU tract procedure; 3) the risk of antibiotic-associated adverse events exceeds the benefit, if any, from prophylactic antibiotic therapy; and 4) maintenance of optimal oral health and hygiene may reduce the incidence of bacteremia from daily living activities and is more important than prophylactic antibiotics for a dental procedure to reduce the risk of IE.[27]

Supporting Evidence

The evidence supporting these conclusions is formidable. Two observational studies found no association between dental treatment and endocarditis.[28,29] None have ever shown any association. These and other studies have concluded that only a very low number of IE cases could ever be prevented with antibiotic prophylaxis prior to dental treatment even if such prophylaxis were 100 percent effective.[30,31] The risks of bacteremia associated with daily living far surpasses any associated with dental treatment: the risk of tooth brushing twice a day for one year has more than 150,000 times greater risk for exposure to bacteremia that a single tooth extraction.[22] The cumulative daily exposure for one year of daily living activities may pose a 5.6 million times greater bacteremic risk than a single tooth extraction.[22]

Possibly the most devastating argument against antibiotic prophylaxis for prevention of dental treatment-induced endocarditis is the absolute risk rate estimation of IE causation. If 250 million people visit the dentist on average of 1.6 times per year (400 million visits per year) and the incidence of infective endocarditis is 11,200 cases annually in the United States with a population of 280 million with a risk rate of 4.0/100,000 population and 25 percent caused by VGS, then the absolute risk rate is 1/142,000 persons for VGS endocarditis if all are caused by dental treatment.[2]

ONLY AN EXTREMELY small number of cases of IE might be prevented by antibiotic prophylaxis for dental procedures.

If it is further assumed that 1 percent of all VGS cases annually in the United States (112 cases) are caused by dental treatment, then the absolute risk rate rises to 1/14,000,000 in the general population with no known cardiac risk factors.[2] The worst-case absolute risk for endocarditis from a single dental treatment procedure rises substantially in persons with known cardiac risk factors: previous endocarditis (1/95,000); cardiac valve prosthesis (1/114,000); rheumatic heart disease (1/142,000); congenital heart disease (1/475,000); and mitral valve prolapse (1/1.1 million).[2,32] Therefore, the number of cases of IE arising from dental treatment is exceedingly small as would be any benefit from antibiotic prophylaxis.[27] It is quite possible the risk of death from penicillin-induced anaphylaxis is greater than any proposed benefit in this scenario.[11,14]

There is no data that bleeding during dental procedures is a realistic predictor of bacteremia.[27] It has always been assumed that if antibiotic prophylaxis reduces the incidence or magnitude of bacteremias, then this is a good surrogate marker for prevention of IE. There is no evidence that this assumption is true.[27]

The absence of evidence is also evidence. There are no consistent data to support the idea that the greater the magnitude of the bacteremia, the greater the risk of IE.[27] The infective dose (inoculum size) of bacteria needed to cause endocarditis is unknown as is the duration of the bacteremia.[27]

Whether a "clean" mouth is more preventive of IE than a "dirty" mouth is contentious since there is only equivocal data to support this assertion.[27] Less than 120 cases of endocarditis due to periodontopathic microorganisms have been reported in the literature with most of these due to *Actinobacillus actinomycetemcommitans*.[2] Viridans group streptococci dominate in a clean, healthy mouth.[27] There are no clinical studies to document that a reduction bacteremias allegedly seen with a healthy mouth reduces the incidence of IE. Practitioners must be careful of surrogate markers and theory falsely rising to the level of fact.

The Role of Microbial Resistance

The world is in the grip of an epidemic of multiple antibiotic resistant microbial

pathogens resulting in more than 18 million deaths annually, not counting AIDS.[33] It is often heard regarding antibiotic prophylaxis that "It's only a single dose!" However, this therapeutic strategy denies the fact that antibiotics are "societal drugs" that affect those nearby (family members) and others globally by fostering the creation of resistant microbes and the transfer their genes.[33,34] The prescriber of antibiotic prophylaxis (or therapy) assumes this is the only time the antibiotic is being used (health care professionals tend to think very locally rather than globally) when it is actually being employed in a similar fashion millions of times per day.

The Lawyers

One of the major factors in the overuse of antibiotics is that they are "drugs of fear" commonly employed to prevent negligence allegations and to assert that "all was done" to treat the patient.[35] This is true with antibiotic prophylaxis probably more than any other application of the drugs. This gross overuse of antibiotics has led to the declining efficacy of the penicillins particularly against oral microorganisms due to microbial resistance, making it even less likely that prophylaxis will be successful.[2,27,33]

Other Observations

A recent feature of endocarditis litigation is the appearance of lawsuits against dentists who followed the 1997 AHA guidelines to perfection; also the inability of medicine to commonly employ the Duke Criteria in the diagnosis of IE.[36,37] Often the disease is "diagnosed" on the basis of a patient-reported fever, one or two positive blood cultures (commonly taken a few minutes apart) and a cardiac murmur with or without a confirmatory echocardiogram for a flail vegetation. This likely leads to a substantial overestimation of the incidence of IE and places at serious risk any attempt by a national registry to document the effect of these new guidelines on endocarditis incidence. If a strict case definition of endocarditis is not employed (unlikely without access to patient records to verify the diagnosis by the Duke Criteria) then the results of such a registry will be very misleading.

Litigation is likely to continue with lawyers attempting to "test the waters" with "experts" who disagree with the preponderance of evidence in the 2007 AHA guidelines. One means of combating these allegations of negligence is to carefully record in the dental records that "in my best clinical judgment" this was the proper treatment of the patient. This need not be restricted to the question of endocarditis prophylaxis but any dental procedure that could be judged improper with the faultless wisdom of hindsight.

EQUALLY REMARKABLE is the ability of the lungs, spleen, liver, and reticuloendothelial system to clear the blood of bacteria.

Dentistry is in danger of creating a similar situation but in reverse. Some are attempting to employ the long-discredited Focal Infection Theory to "prove" the oral cavity, particularly periodontal disease has "systemic ramifications." The current research is limited at best, and, at worst, faulty in its conclusions. It is unlikely that weak odds ratios and wide confidence intervals are going to convince a skeptical scientific community. Claiming that periodontal pathogens are uniquely involved in the infection/inflammation observed in convoluted, sticky atherosclerotic plaque endlessly buffeted by bacteremias is fanciful in the light of the detection of over 50 different microbial species in coronary artery plaque.[38] If the data in the AHA guidelines tell us anything, it is that bacterial assault on the human is unremitting and our welfare utterly dependent on our innate and acquired immune systems along with other factors subsequently discussed, which, from time to time, fail.

Since the incidence and prevalence of IE has not changed with the advent of antibiotic therapy, in spite of all our efforts to reverse this state of affairs, it is likely that other factors are primarily involved.[13] Persons with predisposing factors for endocarditis acquisition are subjected to an endless assault of bacteremias, yet only a few ever develop IE. Certainly the ability of the microorganism to adhere to the valvular vegetation is very important as is the possibility of the organism gaining virulence genes for IE from bacteriophages, plasmids, and transposons.[27,33] The ability of microorganisms to transfer genetic information among themselves is nothing short of remarkable and staphylococci and streptococci are very adept at sticking to surfaces.[33] Equally remarkable is the ability of the lungs, spleen, liver, and reticuloendothelial system to clear the blood of bacteria.

One of the more intriguing aspects of endocarditis is that it may be a platelet disease rather than primarily an infectious one. Platelets are at the very center of IE as they, along with fibrin, form the vegetation that extends from the cardiac valve surface and becomes infected by bacteria. Secondly, the platelets have very significant antibacterial activity both in the blood and at the interface with microorganisms at the surface of the vegeta-

tion. Thirdly, once the vegetation becomes fully established, the antibacterial platelet activity and host defenses may be insufficient to overcome the rapidly multiplying bacteria.[39] Thus, the loss of platelet antimicrobial activity, a deficient innate and acquired immune response, failure to clear the blood of microorganisms, bacterial adhesion factors, and microbial virulence may be at the heart of IE (no pun intended) rather than the bacteremia per se, since it occurs endlessly and rarely produces a problem. As with most calamities, it takes a confluence of deleterious events to create the misfortune rather than a single untoward mishap.

Another interesting aspect of antibiotic prophylaxis is the scant attention paid to the millions who receive the antibiotics but will never benefit from them since the disease to be "prevented" is so rare. Antibiotic prophylaxis in a large population is a poor public health measure since, unlike fluoridation and immunization, where almost all benefit and the risk-benefit ratio is very favorable, antibiotic prophylaxis is rarely, if ever, successful except in hospital situations for surgical infection prevention, and then only under a strict protocol. The principles of antibiotic prophylaxis are well established but rather poorly followed.[2]

Other Antibiotic Prophylaxis Situations

Questions naturally arise as to whether the AHA guidelines apply to other medical conditions that have been proposed for antibiotic prophylaxis. The answer is generally "no." However, the lessons learned can be applied to prophylaxis for dental patients with prosthetic orthopedic joints with even less risk of infection, if any at all, from dental treatment-induced bacteremias. There still is no documented case of a prosthetic joint infection from a dental treatment-induced bacteremia and the risk-benefit ratio is even less than IE.[2]

The subject of other cardiovascular infections due to transient bacteremias has been addressed by another AHA publication with no prophylaxis prior to dental treatment for pacemakers and implantable cardioverter-defibrillators, peripheral vascular stents, prosthetic vascular grafts, coronary artery stents, and left ventricular assist devices.[40] There is no data to support prophylaxis in these situations and the risk from bactermias is very low, if at all. A recent comprehensive study by Lockhart et al. has methodically explored the scientific evidence for antibiotic prophylaxis prior to dental treatment in patients with cardiac-native heart valve disease; prosthetic heart valves and pacemakers; hip, knee, and shoulder prosthetic joints; renal dialysis shunts; vascular grafts; immunosuppression secondary to cancer and cancer chemotherapy; systemic lupus erythematosus; and insulin-dependent (Type I) diabetes mellitus.[41]

The authors found little or no evidence to support antibiotic prophylaxis in these patients or that it prevents distant site infections for any of these eight groups of patients.[41] Other situations for which there is no documented benefit of antibiotic prophylaxis include breast and penile implants and asplenia[42] (**TABLE 2**).

How Did This All Happen?

The propensity for blaming dental treatment procedures for IE arose from several observations and events: 1) the advent and then demise of the Focal Theory of Infection; 2) the discovery that dental procedures induce bacteremias particularly with VGS; 3) that VGS are a common cause of IE; 4) the failure to appreciate random spontaneous bacteremias; 5) inattention to the incubation period of IE; 6) the necessity to find a culprit for the IE, hopefully, a dentist; and that 7), temporal associations are the weakest of all epidemiologic correlations.[26]

Certainly the tendency of the health sciences to concentrate only on the situation at hand (a patient) to the exclusion of any other more global considerations is very common. That antibiotic prophylaxis and antibiotics in general are drugs that affect the entire world population is of little importance. All that counts is this patient in front of me. All must be done to save this one patient to the exclusion of any deleterious effects on others in the population. Even the best of intentions are no substitute for logic and the scientific method.

TABLE 2

Medical conditions for which no antibiotic prophylaxis is recommended before dental treatment.[40-42]

- Arterial grafts
- Asplenia
- Breast and penile implants
- Cardiac pacemakers and implanted defibrillators
- Cerebrospinal fluid shunts
- Dacron carotid patches
- Diabetes mellitus
- HIV/AIDS
- Immunosuppression secondary to cancer/cancer chemotherapy
- Left ventricular assist devices
- Orthopedic pins and screws
- Orthopedic prosthetic joints
- Peripheral and coronary artery stents
- Renal dialysis shunts
- Solid organ transplants without cardiac valvulopathy
- Systemic lupus erythematosus

CDA JOURNAL, VOL 35, Nº7

Dentistry in its passivity basically sat on its hands for more than 50 years and allowed medicine to avoid the necessity to say "I don't know" by blaming us for endocarditis. One wonders what they say when there is no one to blame it on. A corollary is that putting the blame on dentists avoids involvement in litigation.

Lessons Learned

Be wary of the tendency as described by Einstein for "the theory to determine what we observe." Often, scientists find what they want to find, not what they should find. There is an incredible amount of "reverse investigation" going on where the final result is predetermined and only data that supports this conclusion is accepted. Be suspicious when the theory has not passed the test of biologic plausibility (biologic sense).

Does it make sense to give antibiotic prophylaxis to 100,000 to a million individuals to try to save one from IE? What does one do about the 99,999 to 999,999 who will not benefit and will possibly suffer harm? Does it make sense to blame the dentist when it is impossible to determine which bacteremia caused the IE? Does it make sense to say oral bacteria causes cardiovascular disease when this disorder is one of the complicated known to science with up to 200 real or potential markers or risk factors?

An important statistical device that is rarely employed today in clinical studies since it would seriously undermine most health-associated therapies is the concept of the "numbers needed to treat (NNT)" or conversely the "numbers needed to harm (NNH)." This is particularly true for chronic diseases that require long-term longitudinal studies that, unfortunately, are rarely done. It is often assumed that every person who receives periodontal therapy benefits from it. All who receive a statin will likely cheat death from coronary artery disease. The reality is that probably for only a limited number of persons is this true.[43,44]

A NNT analysis will determine the actual number of persons in a given population who will benefit from the drug or procedure, and the NNH the number harmed by the therapy.[43,44]

BE WARY OF

the tendency as described by Einstein for "the theory to determine what we observe."

How many patients will it take to prevent one acute myocardial infarction by "dental treatment"? Is it 1/10, 1/100, 1/1000, 1/10,000 (assuming it has any benefit at all), or in the case of endocarditis prevention approaching infinity? What will the cost be to "save" this one person: $1000, $10,000, $1 million?[45] We simply don't know. Yet our patients have a right to know this.

The cost to "save" one person from an endocarditis death using the 1990 AHA guidelines was estimated to be $3 million per life saved and $300,000 for each case prevented (VGS-associated IE is about 10 percent or less fatal).[42] A numbers needed to treat analysis of all proposed clinical therapies should be mandatory in this day and age of unbridled "scientific" hype, particularly when "published by press release."

What to Do With the Patient and Physician

The most obvious questions about the new AHA endocarditis guidelines is what to say to the patient who has taken antibiotic prophylaxis previously before dental treatment, or their physician who refuses to abide by these guidelines. The guidelines list several talking points as listed previously regarding the much greater risk from random daily bacteremias, the limited efficacy of antibiotic prophylaxis, its potential harm, and the potential benefits of good oral health. This will certainly help to explain the changes and may be all that is necessary. However, these do not address the recalcitrant patient or physician.

Toward this end, the following statement may be appropriate, "These new 2007 American Heart Association (AHA) guidelines for the prevention of infective endocarditis may be confusing to patients who have taken antibiotic prophylaxis in the past prior to dental treatment and are now advised that it is unnecessary. These new recommendations are based upon the best current scientific evidence regarding risk, benefit and efficacy of antibiotic prophylaxis to prevent infective (bacterial) endocarditis. If the physician and/or patient chooses not to follow these recommendations, they do so on their own authority. If the advice of the dentist and AHA are in conflict with that of the physician, then the physician can prescribe the antibiotic prophylaxis on their own authority."

With any dental treatment or decision that may be subjected to the infallible hindsight judgment of a plaintiff attorney or a critical "expert," it would again be wise to place in the dental records the statement that this was determined "by my best clinical judgment." This demonstrates particular attention to a potentially controversial judgment decision. It will be tempting to just go along with the

ill-advised advice of the physician, but two wrongs do not make a right . A primer by Brown et al. addresses the proper format for the dentist-physician consultation.[46]

Clinical Caveats

If the antibiotic dosage is *inadvertently* not administered before the procedure, the drug may be administered up to two hours after the procedure.[27] There is no data to support the concept that preprocedural oral antibacterial rinses prevent IE and are not recommended.[27] Routine dental procedures should be scheduled, if possible, at least 10 days apart if the same prophylactic antibiotic is employed. Alternately, for shorter intervals another approved antibiotic (e.g., clindamycin) can be employed.[27]

Conclusions

The 2007 AHA endocarditis prevention guidelines are a meticulous and expert presentation of the scientific data regarding the prevention of endocarditis by antibiotic prophylaxis. It also establishes, finally, that dental treatment is very rarely, if at all, a cause of IE, and that antibiotic prophylaxis is not established as preventive and should only be employed in the very highest risk patients for the sequellae to IE. The guidelines are strictly evidence-based. Assurances are given that sound new data will be reviewed and incorporated in future guidelines when appropriate as science is a long evolutionary process of discovery. The American Heart Association has done well in following the data. Its critics should do the same. ■■■■

REFERENCES

1. Ashrafian H, Bogle RG, Antimicrobial prophylaxis for endocarditis: Emotion or science? *Heart* 93:5-6, 2007.
2. Pallasch TJ, Antibiotic prophylaxis: Problems in paradise. *Dent Clin North Am* 47:665-79, 2003.
3. Pallasch TJ, Wahl M, The focal infection theory: Appraisal and reappraisal. *J Calif Dent Assoc* 28:194-200, 2000.
4. Pallasch TJ, Wahl M, Focal infection: New age or ancient history? *Endodontic Topics* 4:32-45, 2003.
5. Podgrell MA, Welsby PD, The dentist and prevention of infective endocarditis. *Br Dent J* 139:12-6, 1975.
6. Everett ED, Hirschman JV, Transient bacteremia and endocarditis prophylaxis: A review. Medicine (Baltimore) 56:61-7, 1977.
7. Oakley C, Somerville W, Prevention of infective endocarditis. *Br Heart J* 45(3):233-5, 1981.
8. Guntheroth WG, How important are dental procedures as a cause of infective endocarditis? *Amer J Cardiol* 54:797-801, 1984.
9. Kaye D, Prophylaxis for endocarditis: An update. *Ann Int Med* 104:419-23, 1986.
10. Pallasch TJ, A critique of antibiotic prophylaxis. *J Calif Dent Assoc* 14:28-36, 1986.
11. Tzukert AA, Leviner E, Banoliel R, et al, Analysis of the American Heart Association's recommendations for prevention of infective endocarditis. *Oral Surg Oral Med Oral Path* 62:276-9, 1986.
12. Oakley CM, Controversies in the prophylaxis of infective endocarditis. *J Antimicrob Chemother* 20(Suppl A):99-104, 1987.
13. Young SEJ, Aetiology and epidemiology of infective endocarditis. *J Antimicrob Chemother* 20 (Suppl A):7-14, 1987.
14. Pallasch TJ, A critical appraisal of antibiotic prophylaxis. *Int Dent J* 39:183-96, 1989.
15. McGowan DA, Dentists and endocarditis. *Br Dent J* 169:69, 1990.
16. Pallasch TJ, Slots J, Antibiotic prophylaxis for medical-risk patients. *J Periodontol* 62:227-31, 1991.
17. Simmons NA, Ball AP, et al, Antibiotic prophylaxis and infective endocarditis. *Lancet* 339:1292-3, 1992.
18. Wahl MJ, Myths of dental-induced endocarditis. *Ann Int Med* 154:137-44, 1994.
19. Pallasch TJ, Slots J, Antibiotic prophylaxis and the medically compromised patient. *Periodontol 2000* 10:107-38, 1996.
20. Pallasch TJ, Antibiotic prophylaxis: The clinical significance of its recent evolution. *J Calif Dent Assoc* 25:619-32, 1997.
21. Durack DT, Antibiotics for prevention of endocarditis during dental treatment: Time to scale back. *Ann Int Med* 129:829-31, 1998.
22. Roberts GJ, Dentists are innocent! "Everyday" bacteremia is the real culprit: A review and assessment of the evidence that dental surgical procedures are a principal cause of bacterial endocarditis in children. *Pediat Cardiol* 20:317-25, 1999.
23. Lockhart PB, Durack DT, Oral microflora as a cause of endocarditis and other distant site infections. *Infect Dis Clin North Am* 13(4):833-50, 1999.
24. Lockhart PB, The risk of endocarditis in dental practice. *Periodontol 2000* 23:127-35, 2000.
25. Pallasch TJ, Antibiotic prophylaxis. *Endodontic Topics* 4:46-59, 2003.
26. Wahl MJ, Pallasch TJ, Dentistry and endocarditis. *Curr Infect Dis Reports* 7:251-6, 2005.
27. Wilson W, Taubert KA, et al, Prevention of infective endocarditis. Guidelines from the American Heart Association. A guideline from the American Heart Association rheumatic fever, endocarditis and Kawasaki disease committee, council on cardiovascular disease in the young, and the council on clinical cardiology, council on cardiovascular surgery and anesthesia, and the quality of care outcomes research interdisciplinary working group. *Circulation 2007* Single reprint, (800) 242-8721.
28. Strom BL, Abrutyn E, et al, Dental and cardiac risk factors for infective endocarditis: A population-based, case-control study. *Ann Int Med* 129:761-9, 1998.
29. Lacassin F, Hoen B, et al, Procedures associated with infective endocarditis in adults: A case control study. *Europ Heart J* 16:1968-74, 1995.
30. van der Meer JT, Van Wijk W, et al, Efficacy of antibiotic prophylaxis for prevention of native-valve endocarditis. *Lancet* 339:135-9, 1992.
31. Duval X, Alla F, et al, Estimated risk of endocarditis in adults with predisposing cardiac conditions undergoing dental procedures with or without antibiotic prophylaxis. *Clin Infect Dis* 42:e102-7, 2006.
32. Steckelberg JM, Wilson WR. Risk factors for infective endocarditis. *Infect Dis Clin North Am* 7:9-19, 1993.
33. Pallasch TJ, Antibiotic resistance. *Dent Clin North Am* 47:665-79, 2003.
34. Levy SB, The antibiotic paradox. 2nd ed., Plenum Publishing, Cambridge, Mass., 2002
35. Kunin CM, Editorial response: Antibiotic armageddon. *Clin Infect Dis* 25:240-1, 1997.
36. Durack DT, Lukes AS, Bright DK, Duke Endocarditis Service. New criteria for diagnosis of infective endocarditis: Utilization of specific endocardiographic findings. *Amer J Med* 96:200-29, 1994.
37. Li JS, Sexton DJ, et al, Proposed modification to the Duke criteria for the diagnosis of infective endocarditis. *Clin Infect Dis* 30:633-8, 2000.
38. Ott SJ, El Mokhtari NE, et al, Detection of diverse bacterial signatures in atherosclerotic lesions of patients with coronary heart disease. *Circulation* 113:929-37, 2006.
39. Fitzgerald JR, Foster TJ, Cox D, The interaction of bacterial pathogens with platelets. *Nature Rev Microbiol* 4:445-57, 2006.
40. Baddour LM, Bettmann MA, et al, Nonvalvular cardiovascular device-related infections. *Circulation* 108:2015-31, 2003.
41. Lockhart PB, Loven B, et al, The evidence base for the efficacy of antibiotic prophylaxis in dental practice. *J Amer Dent Assoc* 138:458-74, 2007.
42. Pallasch TJ, Antibiotic prophylaxis. In: Pharmacology and therapeutics for dentistry (Yagiela JA, Dowd FL, Neidle EA, eds.) 5th ed., Elsevier Mosby, St. Louis, 2004.
43. Ebrahim S, The use of numbers needed to treat derived from systematic reviews and meta-analysis: Caveats and pitfalls. *Eval Health Professions* 24:152-64, 2001.
44. Barratt A, Wyer PC, et al, Tips for learners of evidence-based medicine: 1. Relative risk reduction, absolute risk reduction and number needed to treat. *Canad Med Assoc J* 171:353-8, 2004.
45. Hamilton J, The link between periodontal disease and systemic diseases: State of the evidence. *J Calif Dent Assoc* 33:29-38, 2005.
46. Brown RS, Farquharson AA, Pallasch TJ, Medical consultations for medically complex dental patients. *J Calif Dent Assoc* 35:343-9, 2007.

TO REQUEST A PRINTED COPY OF THIS ARTICLE, PLEASE CONTACT Thomas J. Pallasch, DDS, MS, 343 Helmuth Lane, Alexandria, VA 22304.

CDA JOURNAL, VOL 35, Nº7

No Apologies!

That phrase is viewed as an admission of guilt in legalese just the same as it is in your marriage.

Robert E. Horseman, DDS

ILLUSTRATION BY CHARLIE O. HAYWARD

Auto insurance companies have very explicit instructions for their clients who may be involved in an accident. More important than the exchange of licenses and insurance information is the admonition to never volunteer the words, "I'm sorry." Even if you were obviously at fault driving under the influence on the wrong side of the freeway with a 12-pack of empty beer bottles floating around the driver's compartment, "I'm sorry" is an inflammatory phrase that will return to bite you in the fundament. So says the insurance company; so agrees the entire legal defense team. The concept of "not guilty" is so prevalent in today's society with the decline in good manners and common courtesy, one might assume it only surfaced during the turbulent '60s.

Not so. Way back in the beginning of medicine before Harvey and Jenner, before Osler and Lister, before Welby and McDreamy, professional use of "I'm sorry" has been a no-no. A basic canon of medicine has established that time spent cooling one's heels in the reception room or in subsequent examination cells does not require an "I'm sorry" response. This proved so popular, the concept came to include nose jobs, tummy tucks, and pillow lips, as well as a host of other procedures with potentially untoward results.

ProMutual Group, a Boston company that insures 18,000 physicians, dentists, and healthcare facilities in the Northeast, warns its clients against apologies that admit guilt — even in states that have laws protecting doctors who say they are sorry. What! There are states that have such laws? Yes! At least 27 states have passed laws protecting doctors that allow them to use the "S" word when things go wrong without having fear their words will be used against them in court. By extension, this includes "I apologize." That phrase is viewed as an admission of guilt in legalese just the same as it is in your marriage.

CONTINUES ON 529

DR. BOB, CONTINUED FROM 530

As such, it is seldom, if ever, heard. It is so difficult to utter that the last recorded instance of a physicians offering it was an Egyptian doctor to the royal court who mistook tincture of asp venom for powdered rhinoceros horn. He was promptly entombed in an embarrassingly cheesy pyramid while still pleading "'I'm sorry" to the late pharaoh's irate family.

It has become necessary for commiseration to be more sharply defined. While lawmakers in Rhode Island and seven more states are readying laws exempting doctors who, in a freshet of impetuosity, recklessly confess they are sorry for something. "Sorry" is not in the same boat with "apology." You can be sorry for the way things turned out, but in no way is this to be considered an apology for personally being the cause of that result. If this seems to be treading a very fine line, it might be well to have an attorney present before you open your mouth. "The devil made me do it," is not considered a valid argument in a court of law except in certain remote villages in Tanzania.

Trial lawyers, as you might expect, are against anything they didn't initiate themselves.

The medical industry is said to favor this wave of "I'm sorry" laws as a movement to encourage doctors to promptly and fully inform patients of errors in an effort to stave off lawsuits. At the same time the practitioners are warned never to admit errors and to delete the words "mistake," "fault," and "negligence" from their vocabularies. Trial lawyers, as you might expect, are against anything they didn't initiate themselves.

It might be well for medical graduates finishing their residencies to seriously consider postponing practice until they have completed the entire curriculum for a law degree. Or, better yet, skip med school altogether and go straight to law. Lawyers can say anything they want and only other lawyers can understand them. ■■■■