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Compendium

of Continuing Education in Dentistry

Nerve Damage Related to Implant Dentistry

Issues associated with avoiding, diagnosing, and managing damage to the trigeminal nerve

Gary Greenstein, DDS, MS;
Joseph R. Carpentieri, DDS; and
John Cavallaro, DDS

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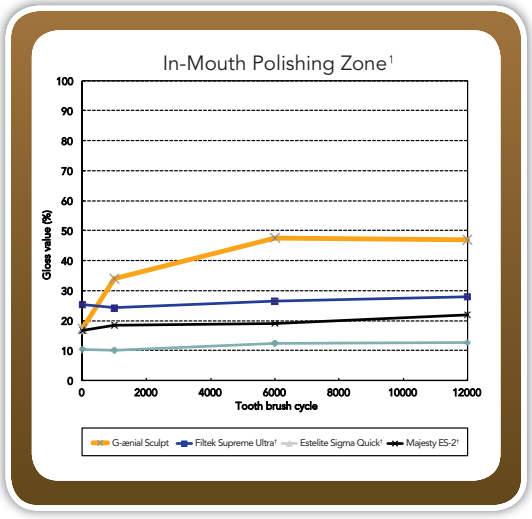

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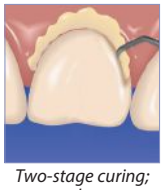
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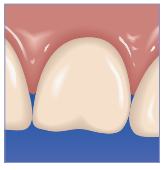
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Patient Management

> Oral healthcare providers need to be aware of potential side effects when prescribing drugs, as some therapeutic medications are directly, or indirectly, associated with dental erosion.

In every specialty and discipline of dentistry, education and research focus on how we can treat our patients more efficiently, effectively, and—most importantly—safely.

Patient management includes patient selection, treatment options, and knowing when to refer a patient to a specialist. Throughout its 36-year history, *Compendium* has played an integral role with regard to this subject. Both of October's Continuing Education articles emphasize the importance of choosing the best course of treatment and discuss the therapies and medications associated with their respective topics.

Although there are many preventive measures in place to preclude nerve damage, it can inadvertently result from treatment. Our first CE article focuses on treatment strategies for nerve damage, particularly when it is related to implant insertion. The authors provide an overview of the various types of nerve damage, present information that will allow clinicians to make an appropriate decision about therapies and medications, and offer advice on when to refer a patient to a specialist.

In a similar vein, oral healthcare providers need to be aware of potential side effects when prescribing drugs, as some therapeutic medications are directly, or indirectly, associated with dental erosion. In our second CE article, the authors discuss various drugs that can lead to dental erosion, and provide precautionary guidelines—The 9 Rs—that can help one avoid or manage medication-induced erosion.

Lastly, in a case report detailing the replacement of a maxillary anterior tooth with a dental implant using immediate implant placement, the authors emphasize the importance of patient selection and working as a team to ensure that the patient is comfortable throughout the process, especially while enduring a state of edentulism.

The art of effective patient management is unique to every practice but ultimately centers on providing the patient with the best care possible. We look forward to your feedback on these articles and others in this month's issue as you consider the authors' techniques and cases in your dental practice. Also, along with viewing our offerings at compendiumlive.com, check out our Facebook, Twitter, and LinkedIn platforms for timely research updates and the latest case studies.

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Compendium
of Continuing Education in Dentistry

October 2015 | Vol.36, No.9 | www.compendiumlive.com

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Printed in the U.S.A.

To order additional copies, call 877-4-AEGIS-1. Subscription rate for 1 year: US $167.00; Canada $200.00; Foreign $234.00.

Compendium of Continuing Education in Dentistry® (ISSN 1548-8578 Print; ISSN 2158-1797 Online) USPS 0566-250 is published monthly, but bimonthly in July/Aug and Nov/Dec by AEGIS Publications, LLC, 104 Pheasant Run, Suite 105, Newtown, PA 18940. Periodical postage paid at Pontiac, IL 61764 and other additional entry points.

Postmaster: Send changes to Compendium of Continuing Education in Dentistry, AEGIS Publications, LLC, 104 Pheasant Run, Suite 105, Newtown, PA 18940

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CONTINUING EDUCATION

CE PLANNING AHEAD

Digital Workflows Using Intraoral Scanning and Restorative Laboratory Surgical Communication

Curtis Jansen, DDS

- Understand the benefits of transitioning from analog to digital processes.
- Describe the various digital workflows that can be incorporated when patient record data from the lab in particular is acquired digitally.
- Differentiate types of architecture and impact on workflow.

Dental Cone Beam Scans: Important Anatomic Views for the Contemporary Implant Surgeon

Gary Greenstein, DDS, MS; Joseph Carpentieri, DDS; and John Cavallaro, DDS

- Identify structures of interest on a CBCT scan.
- Describe how the knowledge pertaining to anatomic structures can facilitate treatment planning.
- Discuss how integrating information from a scan helps to avoid implant complications.

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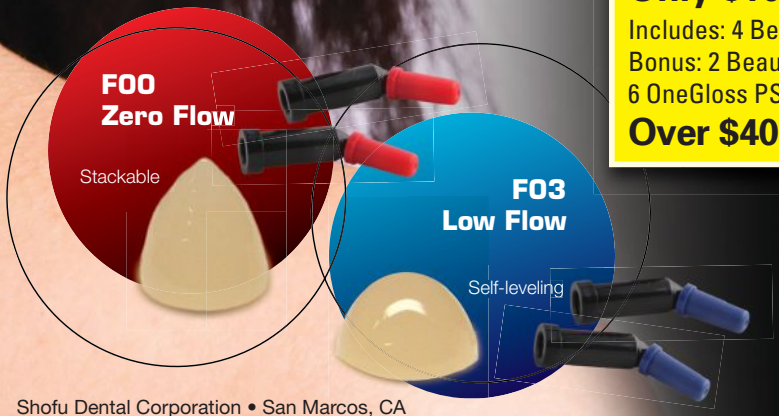

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Laser Dentistry

Robert Levine, DDS; Alan Dalessandro, DDS; David Garber, DMD; and Robert Lowe, DDS, FAGD, FICD, FADI, FACD, FIADE, FASDA

Q: In which applications of dentistry can we expect to see an expansion in the use of lasers?

A: Dr. Levine

As Director of Laser Dentistry at the Arizona School of Dentistry and Oral Health, I am constantly asked by my students about the future of lasers in dentistry. I usually respond by saying that "the sky's the limit." The technology first came to the forefront in 1960, when Theodore Maiman was able to produce laser light from a red ruby crystal. It took almost 30 years to get approval for the first dedicated laser for dental use, which was the Nd:YAG laser in 1989 by Meyers and Meyers. Now, 26 years later, there are both hard and soft-tissue lasers available to the dentist in a variety of wavelengths. Lasers have always had the ability to cut tissues (ablate, vaporize, incise, excise, etc.); however, I feel that our next frontier will be in the arena of therapeutic lasers. To define a therapeutic laser, I think it is only fair to compare it to our traditional photothermal lasers. For a laser to be considered therapeutic, it cannot generate enough heat to break down tissue; therefore, photothermal lasers are not therapeutic. Therapeutic lasers, as defined, are meant to heal.

Low-level laser therapies (LLLT) have been used to treat inflammation, edema, and to repair superficial lesions. The latest models work in modes that are synergistic in nature. Our LEDs, which are monochromatic but not as coherent as are the photothermal laser, are the low-power density models that act fast on inflammation. In low IR range, there are high-power density (HPD) lasers, which have an immediate effect on pain. The HPD laser is in a range where it does not break down tissue, and energy transfer must not be thermal. When used properly, each mode will reciprocally reinforce the other.

It is also important to understand the physiology of the laser process. Pathology in a cell occurs when the balance of adenosine triphosphate (ATP) formation and various metabolic processes lead to pathology in a cell. The cell then passes from an optimal energy state to utilizing its energy to fight off pathology. As a result, the cell becomes stressed, needs to get oxygen back into the metabolic process, and therefore returns to a normal balance.

Tissue inflammation occurs when "ischemic tissue" or "stressed tissue" produces mitochondrial nitric oxide (MTNO). Cytochrome c oxidase (CCO) is a major absorber of red light and near-IR invisible range light. The light absorbed by CCO photo-disassociates the MTNO bond and allows O_2 back into the metabolic system. Thus, we can see an increase in ATP formation and return to cellular balance.

One last aside would be to see the effects a super-pulsed O_2 laser would have on peri-implantitis and laser-supported periodontal therapy. Diode lasers and Nd:YAG lasers are already two big players in this treatment area.

A: Dr. Dalessandro

Speaking from a periodontist's viewpoint, periodontal therapy has always been very evidence-based. So, this had caused the periodontist to overlook the benefits of lasers until recently, as several studies have shown the efficacy of Nd:YAG and Er:YAG lasers in treating periodontitis and peri-implantitis. Several studies show that a combination of both can be very beneficial for enhancing results in traditional and flapless periodontal therapy. The Nd:YAG laser has the benefit of killing black-pigmented bacteria, separating connective tissue from epithelium in the periodontal pocket, and creating a fibrin clot that can contain a host of growth factors. The Er:YAG laser, with the chromophores being more water and hydroxyapatite, can work on root surfaces to clean, detoxify, and actually remove calculus and break apart the walls of bacteria; on implant surfaces, it can also remove calculus, detoxify, and make the surfaces biologically acceptable once again. So, with the advent of both wavelengths, periodontal therapy has been pushed to a new level.

Er:YAG lasers are also used to help de-epithelialize flaps and papillas in gingival grafting, while Nd:YAG lasers can create fibrin clots to enhance bone and soft-tissue healing. Er:YAG lasers have been used in extraction sockets to decorticate and detoxify, and are also very helpful in removing granulation tissue. They can also be used in implant osteotomies to decorticate, detoxify, and stimulate blood flow so that the implant has a good base for healing. The Nd:YAG laser has been used for photobiomodulation, which is otherwise known as low-level laser therapy, in treating postoperative discomfort or myofascial pain and discomfort. Numerous studies have shown how effective it is to reduce oxidative tissue stress in the cells, stimulate ATP, increase blood supply to the area, and help the lymph nodes to become more efficient. This will become bigger and bigger as people realize its benefits. The Er:YAG laser, on the other hand, has been used non-ablatively on the tonsillar pillars, soft palate, and uvula to cause shrinkage of the collagen, thus

stopping or reducing snoring. This procedure is called NightLase® therapy (Fotona, www.fotona.com); it is very effective and now very much in demand.

When I teach laser sciences, I always teach the doctors that they need to be brilliant on basic biology, the procedures they intend to perform, and the physics of lasers and their potential. They could then use a laser as a tool to create a better result than ever before. When this is done, the types of uses are limitless, and the results improve dramatically. So, in the future, my suggestion is to have an open mind, sit back, and watch the body take over with healing from the benefits of laser therapy.

A: Dr. Garber

Recent FDA approval of 9.3-μ CO_2 lasers for use in dentistry, along with beam manipulation technologies commonly used in other industries ranging from tattoo removal to marking plastic bottles, will drive more applications and accelerated adoption of lasers in dentistry.

The original research with 9.3-μ CO_2 lasers conducted at UCSF over 30 years ago was focused on preventing cavities rather than treating them. Now that the FDA has approved the wavelength for cavity treatment, it is only a matter of time until we see the same wavelength used to facilitate long-term cavity prevention.

Because the 9.3-μ laser is so highly absorbed in hydroxyapatite, it can also ablate tooth structure at speeds nearing that of the drill when delivered at higher power levels. Because slow cutting was a major barrier to adoption of previous hard tissue laser technologies, one can expect to see adoption increase dramatically now that that problem is solved. The combination of speed and anesthesia-free treatments saves a lot of time, facilitates multiquadrant dentistry, and sends the patients home smiling. I have to imagine that as more dentists experience this, adoption will increase dramatically.

CO_2 has long been seen as the gold standard for soft-tissue cutting, but it was hard to rationalize the expense with low-cost diodes and other alternatives. Now that CO_2 can be used on both hard and soft tissue without switching tools, it makes economical sense to have it in the operatory. It is wonderful to simply push a button and switch from bloodless soft-tissue ablation to high-speed enamel ablation without having to administer anesthesia.

A: Dr. Lowe

Lasers have been utilized in dentistry for almost two decades, and in medicine and ophthalmology even longer. The minimally invasive nature of lasers, along with improved tissue response and healing, has made them a very attractive technology for dental procedures accomplished in the microenvironment of the oral cavity.

So, where in dentistry can we expect to see an expansion in the use of lasers in the near future? Personally, I have used lasers in my practice since the early 2000s. I cannot imagine practicing restorative dentistry without them. For contouring soft tissue with little to no necrosis, soft-tissue crown lengthening for restorative access, and minor hard-tissue re-contouring for biologic width violation (Erbium wavelengths only), lasers make the work easier and the outcomes better than many of the "conventional" therapies. Accessibility and affordability of laser technology will continue to drive adoption with dentists, providing wider access to laser care for patients; if you follow almost all other technology trends, especially in dentistry, things come down in price and settle in at a price point that equates the device's value, eg, intraoral cameras, digital x-ray sensors, etc. In the case of lasers, diodes have already realized this trend, with a drop in price over the last 5 to 10 years that has driven the adoption rate as high as 50% of all dentists. All-tissue lasers remain a niche product, but one can expect some laser manufacturer to break through with an economical, practical version, which will drive widespread adoption, as it did with diodes, especially as general dentists continue to understand the excellent outcomes all-tissue lasers offer.

Also, as research with lasers continues, there will be more step-by-step protocols for specialists and general dentists to simplify the delivery of laser care to patients. One emerging trend is that of peri-implantitis treatment and the rescue of failing implants. Inflammatory tissue can be safely removed from the implant surface with an Erbium wavelength laser allowing the dentist to bone graft and potentially recover from implant failures.

Also, one of the most appealing applications of an all-tissue dental laser is the notion of performing cavity preparations without using a high-speed drill and local anesthesia. Despite claims from various manufacturers through the years, it is still a fact that performing a cavity preparation without a handpiece and local is not universal or predictable enough to incite widespread adoption, yet. In general, laser technology that is designed to ablate enamel, dentin and bone has seen numerous advances since the notion of cutting a cavity preparation with a laser was first investigated in the late 1980s and early 1990s, but this application needs further innovation, which, according to many laser companies, remains a major focus in their research and development efforts. I would expect scientific and technological innovation that will move cavity preparations toward no-shot, no-drill reality.

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Format: Lecture
Tuition: $250
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Place: UCLA School of Dentistry, Los Angeles, CA
Register: 310-206-8388| dentistry.ucla.edu/learning/continuing-dental-education

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Format: Lecture/Hands-on
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CE Credit: 16 credit hours
Place: University of Tennessee Health Science Center College of Dentistry, Memphis, TN
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Thomas Kunkel, DMD

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Format: Lecture/Hands-on
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CE Credit: 6 credit hours
Place: University of Pittsburgh School of Dental Medicine, Pittsburgh, PA
Register: 412-648-8370 | dental.pitt.edu/continuing-education

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Emilio Arguello, DDS, MSC | Eduardo Marcuschamer, DDS

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Register: 617-636-6629 | dental.tufts.edu

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Place: NSU Health Professions Division, Davie Campus, Fort Lauderdale, FL
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IMPLANT-RELATED NERVE DAMAGE

Nerve Damage Related to Implant Dentistry: Incidence, Diagnosis, and Management

Gary Greenstein, DDS, MS; Joseph R. Carpentieri, DDS; and John Cavallaro, DDS

LEARNING OBJECTIVES

- discuss and differentiate between signs of nerve damage
- explain when to refer a patient to a microsurgeon if there are altered neural sensations
- describe techniques that will help to avoid nerve injuries

Abstract: Proper patient selection and treatment planning with respect to dental implant placement can preclude nerve injuries. Nevertheless, procedures associated with implant insertion can inadvertently result in damage to branches of the trigeminal nerve. Nerve damage may be transient or permanent; this finding will depend on the cause and extent of the injury. Nerve wounding may result in anesthesia, paresthesia, or dysesthesia. The type of therapy to ameliorate the condition will be dictated by clinical and radiographic assessments. Treatment may include monitoring altered sensations to see if they subside, pharmacotherapy, implant removal, reverse-torquing an implant to decompress a nerve, combinations of the previous therapies, and/or referral to a microsurgeon for nerve repair.

Patients manifesting altered sensations due to various injuries require different therapies. Transection of a nerve dictates immediate referral to a microsurgeon for evaluation. If a nerve is compressed by an implant or adjacent bone, the implant should be reverse-torqued away from the nerve or removed. When an implant is not close to a nerve, but the patient is symptomatic, the patient can be monitored and treated pharmacologically as long as symptoms improve or the implant can be removed. There are diverse opinions in the literature concerning how long an injured patient should be monitored before being referred to a microsurgeon.

Damage to a branch of the trigeminal nerve (eg, inferior alveolar, lingual, mental, and infraorbital nerves) is a potential untoward consequence of performing implant dentistry. Injury to a nerve can occur due to direct trauma, inflammation, or infection.[1] Harm can happen during the following procedures: anesthesia, flap elevation or advancement, harvesting a bone graft, preparing an osteotomy, and implant placement. Because repair of a damaged nerve is problematic, wound avoidance is critically important. Therefore, knowledge is necessary regarding oral nerve anatomy, histology, familiarity with signs and symptoms of nerve damage, and testing for the presence of a neuropathy. Upon diagnosis of nerve injury, a decision must be made with respect to monitoring and documenting symptoms, pharmacologic therapy, implant removal, patient referral for nerve repair, or combinations of the previous concepts. This article addresses multiple issues associated with avoiding injuries and managing patients who experience damage to the trigeminal nerve due to dental implant-related procedures.

Trigeminal Nerve Anatomy and Histology

The trigeminal nerve is the fifth and largest cranial nerve.[2] It has three main branches: ophthalmic (V1), maxillary (V2), and mandibular (V3). The mandibular segment is the largest branch and innervates the mandibular lip, chin, teeth, adjacent soft tissues, mandible, and part of the external ear. The motor fibers of the mandibular branch are not subject to injury during implant procedures, because they separate from V3 before they exit the foramen ovale.[3]

The basic unit of a nerve is a fiber.[4] Myelinated nerve fibers predominate in V3. A single nerve axon and a Schwann cell are encased in a connective tissue covering called *endoneurium*. Groups of encased nerve fibers are referred to as a *fascicle* and they are surrounded by perineurium. A group of fascicles is surrounded by

epineurium. Damage to any part of the nerve bundle can result in neurosensory impairment.

The trigeminal nerve has 7,000 to 12,000 axons and the number of fascicles varies in different regions of the mouth.[5] The inferior alveolar nerve (IAN) is polyfascicular (>10 fascicles), whereas the lingual nerve (LN) has few fascicles.[6] Because the IAN has more fascicles than the LN, it has greater capacity to repair after injury due to innervation from uninjured fascicles.[3]

Types of Nerve Damage

Injuries to the trigeminal nerve can include compression, stretching, and partial or complete transection. Damage can result in neurosensory alterations with respect to touch, pressure, temperature, and pain.[7] Trigeminal nerve malfunctions can interfere with speaking, eating, kissing, shaving, applying makeup, toothbrushing, and drinking.[7] In addition, these injuries can have psychological effects and affect social interactions.[8] Altered sensations (eg, pain) may be detected during surgical manipulations or there may be a delayed onset of discomfort.

Terms used to describe injuries with respect to axonal damage are listed:[9]

- *Neurapraxia:* There is no loss of continuity of the nerve, but it has been stretched or undergone blunt trauma. The altered sensations will subside and feeling returns in days to weeks.
- *Axonotmesis:* The nerve is damaged, degeneration and regeneration occur, but the axon is not severed and feeling returns within 2 to 4 months. Eventual recovery of sensation is often less than normal, and it may be accompanied by dysesthesia.
- *Neurotmesis:* The nerve is severed and there is a poor prognosis for resolution of all neurosensory alterations.

The International Association for the Study of Pain standardized nomenclature concerning nerve injuries. In particular, they altered the definition of *paresthesia*, which used to denote loss of feeling.[10] Currently, the following definitions are employed:

- *Paresthesia:* Altered sensation that is not unpleasant (eg, pins and needles).
- *Dysesthesia:* Altered sensation that is unpleasant.
- *Anesthesia:* Loss of feeling or sensation.

Other terms used to describe changed responses include: *allodynia*—pain to a stimulus that does not normally hurt; *causalgia*—persistent burning pain; *hypoesthesia*—decreased sensitivity to stimulation; and *hyperesthesia*—increased sensitivity to stimulation.[10]

When nerves are stretched or compressed, the perineurium protects the fascicles. However, elongation >30% can result in structural failure of the nerve.[11] With respect to partial or complete transection of a nerve, total transections usually cause an anesthetic response with poor function. In contrast, partial nerve injuries can have a varied response with respect to dysesthesia.[11] Others mentioned that persistent postsurgical pain is a poor predictor for spontaneous rejuvenation of a nerve injury.[12,13]

Subsequent to peripheral nerve injury, Wallerian degeneration starts and continues over weeks to months.[14] Distally, past the place of injury, the axons undergo necrosis. This degeneration is progressive and becomes irreversible at zero to 18 months.[14] Factors affecting healing include the patient's general health, age, and type of injury.[14] A defining moment for the damaged nerve is reached when a large mass of endoneurial tubules has changed into scar tissue.[15]

Assessing Patients' Injuries Concerning the Trigeminal Nerve

The most commonly injured nerve during implant dentistry is the IAN.[3,16] Damage to this structure may manifest itself as anesthesia or paresthesia or dysesthesia of the skin adjacent to the mental foramen, the lower lip, buccal mucous membranes, and gingiva as far posteriorly as the second molar.[17] In contrast, patients with an LN injury may report drooling, tongue biting, burning, loss of taste, changes in speech, swallowing, alterations of taste perception, and numbness of the lingual mucosa or tongue.[15]

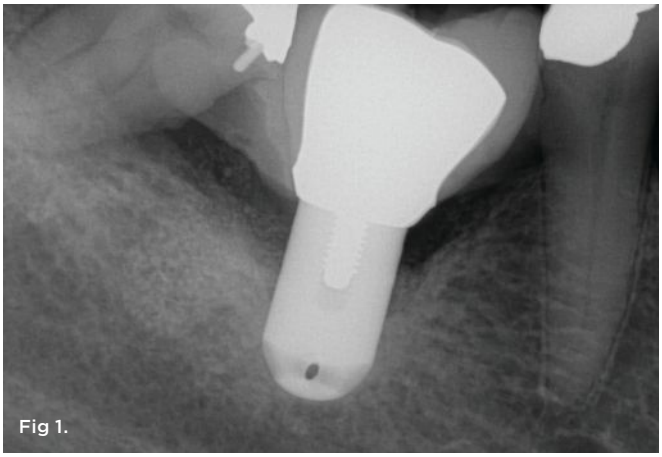
During surgery or post-implantation, all signs or symptoms (eg, pain, altered sensation, numbness) of a nerve injury should be documented. Areas of neurosensory deficit should be mapped (eg, altered sensation areas ought to be measured in millimeters). This will facilitate monitoring recovery and help determine if micro-reconstructive surgery may be needed.[17] Both subjective and objective sensory tests can be employed to document and evaluate injuries. There are two basic categories of tests: mechanoceptive (response to mechanical pressure or distortion) and nociceptive (perception of pain) (Table 1). Mechanoceptive tests include static light touch, two-point discrimination, and brush-stroke direction.[18,19] Pin-tactile discrimination and thermal testing are nociceptive tests. The side opposite to the injury should be stimulated to help confirm there has been an alteration of sensation at the supposedly damaged location. If loss of taste was reported, it can be assessed with salt or sugar on a cotton swab.

Incidence of Nerve Injuries

Subsequent to implant procedures, the occurrence of permanent nerve damage that results in altered lip sensations ranges from 0% to 36% in different studies.[20-22] However, citations of old literature can be misleading and not relevant to contemporary implant dentistry. Historically, many damaged nerves may have been due to vestibular incisions that were employed to facilitate implant placement. Currently, midcrestal incisions are usually used and computerized tomography helps avoid injuries. In this regard, recent articles have noted injury rates lower than previously reported. Dannan et al reported a transient trigeminal nerve damage rate after dental implants of 2.95% (5/169 patients) and 1.7% of the patients had permanent neuropathy.[23] Another recent university study in an outpatient setting indicated an injury rate of 2.69% (42/1,559) after oral surgical procedures and the permanent injury rate was less (not reported for all types of surgery).[24] In the authors' opinion, even these reduced incidences of nerve damage are too high. It should also be noted that transient altered lip sensations can be due to edema for 1 to 2 weeks and are not considered nerve damage.

Lingual Nerve Damage During Surgical Procedures

The LN in the mandibular molar areas resides within the lingual soft tissue. It may be coronal to the bone within the tissue and lies close to the lingual cortical plate.[25] Therefore, caution must



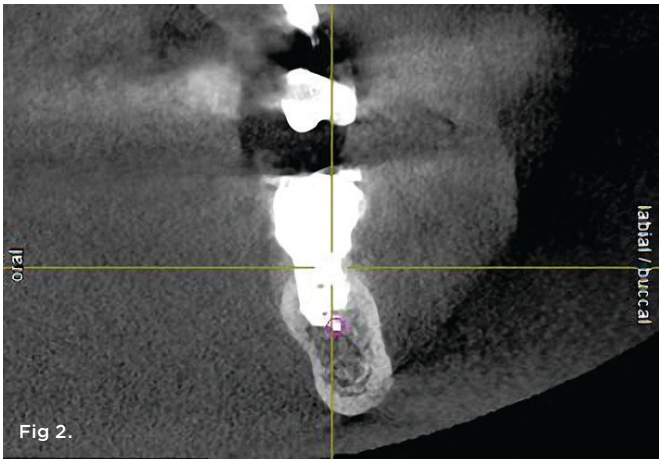


Fig 1. An implant was placed at site No. 30. Immediately after the effect of the local anesthesia subsided the patient complained of paresthesia (no pain) of the mandibular right lip and chin. A periapical radiograph taken at the time of implant placement demonstrated no apparent implant penetration into the inferior alveolar canal. **Fig 2.** The implant restoration was completed 10 years ago and the patient has been able to accommodate the altered nerve sensation. Recently, the patient presented at one of the authors' offices and a CBCT scan was ordered. It demonstrated that the implant at site No. 30 is closer to the inferior alveolar canal than previously envisioned and may be causing compression on the nerve.

be exercised when performing surgical procedures in this region. After third-molar removal, damage to the LN occurs 0.5% to 2.1% of the time.[26] However, it is unusual for the LN to be damaged during periodontal or implant surgery.[27] As a general rule, implants placed in the mandibular molar region should be performed as follows: intrasulcular incisions, no vertical releasing incisions on the lingual aspect, and a full-thickness mucoperiosteal flap on the lingual aspect; avoid overstretching the flap and maintain safety distance to the nerve when creating the osteotomy. It has been documented that around 90% of LN injuries are transitory and resolve 8 to 10 weeks postoperatively.[28]

Preoperative Planning: Preventing Nerve Injuries

To ensure correct implant placement with the least amount of complications, preoperative planning is necessary. Avoiding nerve injuries starts with proper patient selection, which is done in association with good diagnostics. If it is believed that a computerized tomography (CT) scan or surgical guide would be beneficial, then it should be utilized. Individuals performing surgeries must confirm the path of the mandibular nerve that may have been outlined on a scan by a radiologist. When placing dental implants, a 2-mm safety zone should be left apical to implants over the IAN to accommodate minor drilling errors and drill lengths should be adjusted to take into account radiographic distortion.[19,29] In addition, the 2-mm safety zone may help avoid pressure placed on the nerve due to bone compression when the implant is placed close to the mandibular or mental canals (Figure 1 and Figure 2). If necessary, short implants can be used to remain in the safety zone.[30] Clinicians should also be aware that drill markings to denote bur length do not take into consideration the extra length of the tapered drill tip, which can add anywhere from 0.4 mm to 1.5 mm to the actual drill size.[19,31] In addition, over the IAN or mental nerve, it is advantageous to use drill stops to avoid over-drilling.[19,31] It should be underscored that the thickness or density of the bone surrounding the IAN does not provide substantial resistance to drill penetration and excess force should be avoided when drilling over the IAN.[32]

Finally, it should be noted that 50% of lawsuits related to nerve injury after implant therapy are associated with a lack of informed consent obtained prior to surgery; thus this document must be signed by the patient.[33] It also is a good idea to do a neurosensory assessment before initiating procedures to rule out pre-existing sensation impairments.[16]

Local Anesthesia: Potential to Cause Nerve Damage

Injury to the IAN or LN can occur during block injections due to needle trauma, hematoma formation, or injected chemicals.[17] However, it is unknown how the needle or injection ingredients cause nerve damage. In one retrospective study, it was estimated that the incidence of nerve injury was 1/26,762 to 1/160,571,[6] whereas Haas and Lennon[34] projected it happened 1/785,000. Others, after assessing the literature, indicated the incidence of short-term impaired LN and IAN damage after injections was 0.15% to 0.54%,[26] whereas permanent damage due to injection of local analgesics is very unusual, at 0.0001% to 0.01%.[35]

When performing a mandibular block injection, patients may feel an electric shock around 3% to 7% of the time.[36,37] Needle trauma usually resolves spontaneously.[37] However, when a clinician sees a patient react (wince in pain) to an injection, the needle should be withdrawn a little and repositioned. Furthermore, with respect to nerve damage due to local anesthesia, there is no known treatment or method of prevention,[6] besides avoiding block injections.

It has been noted that 70% to 89% of the injuries that occur as a result of block injections are to the LN.[38,39] A possible explanation for this is that the LN has few fascicles, whereas the IAN is polyfascicular and has a greater potential for healing. From a geometric perspective, which may influence the potential for damage or repair, the tip of a 25-gauge needle is 0.45 mm, and the LN and IAN are 1.86 mm and 3 mm wide, respectively.[40,41]

After block injections, the greatest incidence of neuropathy occurred among individuals who were injected with 4% articaine

or prilocaine.[39,42] Studies assessing 4% prilocaine and 4% articaine noted an increased number of neuropathies occurred when compared to lidocaine, 7.3 and 3.6 times more, respectively.[36,43] Garisto et al reported 4 of 9 investigations that demonstrated 4% prilocaine or articaine was associated with a higher incidence of paresthesia than anesthetics with lower concentrations.[39] They and others believe that regional blocks with these drugs should be avoided to reduce the risk of creating a neuropathy.[39,42] However, Malamed indicated there was no supporting data besides anecdotal reports that articaine caused an increase in neurosensory alteration when compared to lidocaine.[44] Similarly, in 2013, after an extensive literature review, Toma et al concluded that studies suggesting articaine caused increased neurotoxicity were retrospective, biased in data recruitment, and provided a low level of evidence.[45] They concluded that procedural trauma emerged as a valid explanation for reported neurological issues. There is controversy in the literature regarding this issue; therefore, clinicians need to make decisions with respect to using higher concentrations of anesthetics based on the data in the literature, their interpretation of this information, and recommendations by drug manufacturers.

Osteotomy Preparation for Dental Implants

Osteotomies should be prepared using sharp drills with copious irrigation. Conceptually, it is possible that too much generated heat could result in postoperative nerve damage.[46] The size of the necrotic areas induced by heat is directly proportional to the heat generated during the surgery.[47] Eriksson and Albrektsson suggested 47º for 1 minute could produce bone resorption.[48] However, the few seconds used to drill an osteotomy probably will not cause nerve damage.

When there is advanced resorption of the mandibular alveolar ridge the position of the mental foramen may be at the alveolar crest; therefore, a midcrestal incision in the edentate area is contraindicated. The incision should be made on the lingual aspect of the ridge to avoid injuring the emerging mental nerve.[19,39]

If an implant is to be placed anterior to the mental foramen and its length is greater than the distance from the alveolar ridge to the infundibulum of the mental foramen, it is important to verify with a CT scan that there is no anterior loop to the mental nerve.[39]

Flap Advancement Procedures

Flap advancement will not usually predispose a patient to nerve damage, but caution must be exercised especially in the mental foraminal area.[49] In this regard, the clinician should know precisely where the mental nerve emerges from the mental canal to avoid damaging the nerve when a flap is advanced in this region.

Extracting Teeth

Before extracting a mandibular molar or premolar in preparation for an implant, assess the location of their roots in relation to the IAN and mental nerve, because if a nerve is juxtaposed to the roots of teeth, tooth removal has the potential to induce nerve damage. Furthermore, caution should be exercised when debriding large periapical radiolucencies, because these lesions may communicate with a nerve canal (Figure 3 and Figure 4).

Pharmacologic Therapies for Neuropathies Associated with Dental Implant Placement

There is no consensus with respect to use of pharmaceuticals after a nerve injury. However, some authors suggest the use of corticosteroids and nonsteroidal anti-inflammatory drugs (NSAIDs).[3,12,16,19,50-53] Pharmaceuticals may be appropriate when signs or symptoms of neurosensory alterations occur and the clinician is certain that the nerve was not transected.

Table 2 lists several situations where drug application may be beneficial. In conjunction with pharmaceutical intervention, Renton and Yilmaz recommend that patients with chronic neuropathy engage in psychological counseling with respect to pain management.[12] The goals of these therapies are to decrease discomfort and to help patients manage their pain. Contrastingly, Bagheri and Meyer stated that it is unlikely that corticosteroids would be of benefit after injury of the IAN, because it is contained within the inferior alveolar canal and drug penetration would be minimal.[54] Pertinently, no clinical

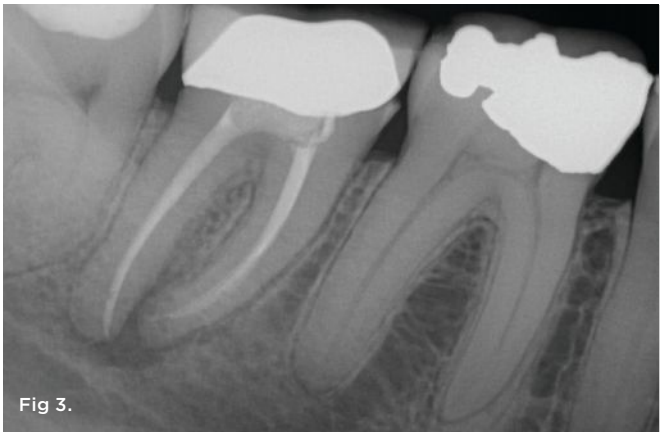


Fig 3.

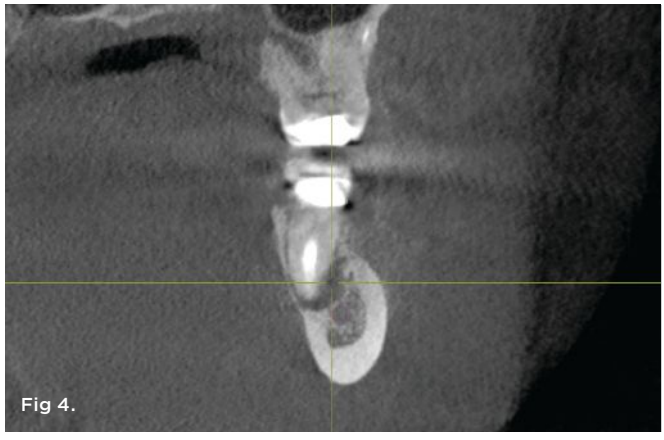


Fig 4.

Fig 3. A patient presented with intense pain in tooth No. 31. A periapical radiograph demonstrated acute apical periodontitis. It was not possible to identify the extent of the periapical lesion with respect to the inferior alveolar canal. **Fig 4.** A CT scan was obtained. The scan demonstrated the proximity of the apical lesion to the canal. With proper preoperative planning and imaging, the tooth was successfully removed and the granulomatous tissue carefully debrided without inducing any altered nerve sensation.

trials were found that investigated the use of corticosteroids or NSAIDs after nerve injury caused by dental implants.

When to Refer a Patient to a Microsurgeon

At present, there are no uniform guidelines concerning when a patient with an injured trigeminal nerve should be referred to a microsurgeon. If altered sensations occur post-implantation, some authors suggest immediate referral.[33] Others recommend seeking consultation after different monitoring intervals: 2 months,[19,55] 3 months,[3,14] before 4 months,[18] and 3 to 6 months.[56] Ziccardi and Zuniga stated that microsurgery should be done before 1 year, because after that the surgery's efficacy is diminished.[57]

Subsequent to nerve injury, the clinician needs to determine if immediate referral is necessary or a pharmacologic approach is warranted or if implant removal or reverse-torquing it a little would best serve a patient. There are diverse opinions in the literature pertaining to when and under what conditions referral to a microsurgeon is needed.[58,59] It is generally agreed that if a clinician believes that a nerve has been transected as a result of an implant procedure, immediate referral is warranted.[12,51,54,60,61] On the other hand, if a patient manifests neurologic symptoms post-implantation, but the clinician is sure that the drill never entered the mandibular canal, it is possible that postoperative altered sensation is caused by traction of a nerve or an inflammatory process. Then a pharmacologic approach may be warranted.[3] A clinician can be almost sure that the drill did not enter the mandibular or mental canal if after each drill, the floor of the osteotomy was checked with an implant probe or if a radiograph clearly depicts the osteotomy terminated several millimeters from the nerve canal. The previous remark is qualified, because there is the remote possibility that some unusual branch of the IAN was present and damaged. From another perspective, a CBCT scan can be ordered to attain an enhanced view of the implant's relationship to vital structures if a 2-dimensional radiograph was initially used to assess the situation (Figure 1 and Figure 2).

With respect to discomfort after implant placement, if it can be confirmed that the implant is not near the nerve canal, there are different recommendations. Bagheri and Meyer suggest waiting 3 to 4 months to see if altered sensations improve before referring a patient to a microsurgeon.[14] They also advise that if an implant is close to the nerve, it could be reversed a little to decrease bone

TABLE 1

Tests to Determine if Neurosensory Damage Has Occurred

Light touch test	A soft brush is applied to the lip and the patient is asked in which direction the stimulus was applied.[18]
Pain test	A 27-gauge needle can be used to determine whether the patient perceives pain.[18]
Two-point discrimination test	Calipers could be opened progressively at 2-mm increments until the patient is able to discriminate the caliper ends as two separate points of contact.[19]
Temperature test	Ice or a heated mirror handle (43°) can be used to determine if the patient is able to discriminate between hot and cold.[19]

TABLE 2

Suggested Pharmacotherapies for Trigeminal Nerve Injury Associated with Implant Placement

CONDITION	THERAPY
Altered sensation due to injection	Immediate dexamethasone 4g/ml injection into site, then 3 days of decreasing steroid doses.[3]
Traction or compression of nerve trunk or trauma during surgery	1 ml to 2 ml of IV form dexamethasone (4 mg/ml) topically applied for 1 to 2 minutes, then 6 days oral dexamethasone (4 mg, 2 tabs AM for 3 days, then 1 tab AM for 3 days).[3]
Nerve injury	Tapering dose of steroid for 5 to 7 days.[19] Note: Dexamethasone 8 mg to 12 mg has greater anti-inflammatory effect than other corticosteroids.[50]
Altered sensation	800 mg ibuprofen three times a day, for 3 weeks.[19]
Neuropathy followed by implant removal	Ibuprofen 800 mg three times a day, amoxicillin 500 mg three times a day, for 5 to 7 days, and prednisolone 50 mg once daily for 5 days with step down of 10 mg per day for 5 days.[51]
Chronic neuropathy	Engage in counseling and possibly the application of 5% lidocaine patches.[12]
Post-traumatic neuropathy	Low-dose antidepressants, antiepileptics.[12,52,53]

compression. Contrastingly, after surgical placement, if a patient has neurosensory discomfort, despite no apparent transection of the nerve, it was recommended to remove the implant within 36 hours and prescribe a steroid.[33,51] Pertinently, Khawaja and Renton discussed four cases where patients became symptomatic after implant placement without apparently encroaching upon the IAN.[51] The implants were removed, and then two of the four patients' neural issues quickly resolved.[12] With respect to the four cases, implants were removed after 18 and 36 hours vs 3 and 4 days.

With regard to the controversy as to whether surgical intervention is needed prior to 3 months if there is no observed transection of the nerve—there is no definitive answer.[58] Renton, Dawood, and colleagues suggest that clinicians should not wait too long, because after 3 months they believe neural changes occur that diminish positive responses to microsurgical repair.[59] Contrastingly, Ziccardi and Steinberg in their review article suggest that when there are altered sensations, but unobserved damage to the nerve, the patient should be monitored for 1 month, and as long as symptoms are improving, monitoring should be continued.[58] However, if there is no improvement, or pain worsens, consider microsurgery. It was concluded that patients treated 6 to 8 months after injury do as well as patients treated earlier.[58] They pondered that earlier intervention may be better, but at present the data does not support this conclusion. It was also mentioned that minor altered sensations are best left untreated, because surgery is not totally predictable to achieve a desired result.

Others mentioned the "12 week rule," which refers to the timeline in which surgeons often wait before making decisions about microsurgery for the patient who manifests intolerable continual loss of sensory function.[54] This monitoring period would be curtailed for a patient who has pain. In summary, the patient's radiographic and clinical findings, symptoms, and concern about neural scarring dictate when a patient should be referred for microsurgical consultation. Pertinently, there are medico-legal considerations with respect to a timely referral. Therefore, when in doubt pertaining to the etiology of altered neurosensory issues, early transfer to a nerve specialist is prudent.

Surgical Repair of a Damaged Trigeminal Nerve

There are specific reasons for undergoing nerve repair and different factors impact the success of these procedures. Ziccardi and Zuniga listed several indications for microsurgery: altered sensations that persist for more than 3 months and interfere with daily functions, observed nerve transection, no improvement of hypoesthesia, or development of pain caused by nerve entrapment.[57] When nerve repair procedures are performed, numerous factors can affect the results: time between injury and repair, the type and extent of injury, the vascularity of the injury site, skill of the surgeon, harvesting and preparation of the graft, the tension (if any) across the repair, and the age and general health of the patient.[60]

Microsurgical repair of injured branches of the trigeminal nerve (IAN and LN) can be accomplished.[62] However, the successful repair rate and amount of sensory restoration are variable (Table 3).[60,62-66] Furthermore, it should be noted that most of the cited studies had limited populations and the final assessment methods were different; therefore it is not possible to directly compare the success rates of these studies.

It appears that 50% to 60% of the time there is a perceived neurological improvement by patients after microsurgery. However, Ziccardi and Zuniga caution that patients with moderate to severe nerve damage need to be informed that they will not usually experience complete sensory recovery.[57] Pertinently, others lamented that the success of microsurgical procedures has been overstated and that signs of anesthesia, dysesthesia, and spontaneous pain are negative predictors for repair even with surgical interventions.[51] Overall, it can be concluded that microsurgery can help some individuals; however, it cannot predictably resolve all issues.[63] Therefore, prevention of injuries is the best way to ensure patients a speedy recovery after dental implant procedures.

Conclusion

There are situations when a decision must be made as to whether to retain an implant that is osseointegrated, but its insertion has caused a tolerable paresthesia (no pain). There are two sides to this dilemma. Implant removal may not improve the patient's altered sensation; therefore, the implant can be restored. On the other hand, a patient must be informed that there is a remote possibility that a traumatic neuroma could form if an implant rests on a damaged nerve. A neuroma results from exaggerated neural healing and hyperplasia and may need to be surgically removed. To take into account both points of view, a treatment plan needs to be made after discussion with a patient and this conversation should be documented in the chart.

TABLE 3

Response to Microsurgical Repair of Branches of the Trigeminal Nerve

STUDY	PATIENT RESPONSES*†
Bagheri et al[60]	81.7% surgical mending of the IAN
Susarla et al[62]	63.1% rated their satisfaction as good to excellent for trigeminal nerve repair
Pogrel[63]	59.4% showed some improvement of cases concerning the IAN and LN
Lam et al[64]	55% rated their overall satisfaction as good to excellent for IAN and LN repair
Strauss et al[65]	54.9% of the patients who had surgical repair of the IAN had a significant improvement
Gregg[66]	50% overall reduction in pain severity

**Patient responses listed as reported in articles.*
† Listed in decreasing order of success.

DISCLOSURE

The authors had no disclosures to report.

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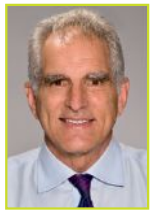

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QUIZ

Nerve Damage Related to Implant Dentistry: Incidence, Diagnosis, and Management

Gary Greenstein, DDS, MS; Joseph R. Carpentieri, DDS; and John Cavallaro, DDS

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1. **If the clinician believes a nerve has been transected as a result of an implant procedure, it is generally agreed that what is warranted?**
   A. pharmaceutical therapy
   B. referral to a microsurgeon
   C. monitoring the area for 3 months
   D. placing the implant short of the nerve canal

2. **Which is the largest branch of the trigeminal nerve?**
   A. maxillary nerve
   B. inferior alveolar nerve
   C. lingual nerve
   D. mandibular nerve

3. **A fascicle is composed of what structures?**
   A. a group of nerve fibers
   B. groups of epineuria
   C. a group of perineuria
   D. groups of endoneuria

4. **What distinguishes neurotmesis from other conditions?**
   A. the nerve is not severed
   B. the nerve is severed
   C. the nerve regenerates
   D. the nerve invaginates

5. **What is the current definition of paresthesia?**
   A. loss of feeling
   B. altered sensation that is unpleasant
   C. altered sensation that is not unpleasant
   D. continuous pain

6. **Elongation of a nerve by more than what percentage can result in its structural failure?**
   A. 10%
   B. 20%
   C. 30%
   D. 40%

7. **If a patient has altered sensation after an implant placement, when might he or she not be referred to a microsurgeon?**
   A. if symptoms are getting better
   B. if symptoms are getting worse
   C. if pain is increasing
   D. if pain is continuous

8. **Methods to avoid causing mandibular nerve damage include which techniques?**
   A. using drill stops
   B. leaving a 2-mm safety zone over the nerve
   C. accounting for the extra length of the tapered drill tip, which can add to the actual drill size
   D. All of the above

9. **What percentage of the time does it appear that there is a perceived neurological improvement by patients after microsurgery?**
   A. 20% to 30%
   B. 30% to 40%
   C. 50% to 60%
   D. 60% to 70%

10. **To avoid nerve damage when the mental foramen is at the alveolar crest, an incision should be:**
    A. midcrestal.
    B. on the lingual aspect of the mandibular alveolar ridge.
    C. on the buccal aspect of the mandibular alveolar ridge.
    D. vestibular.

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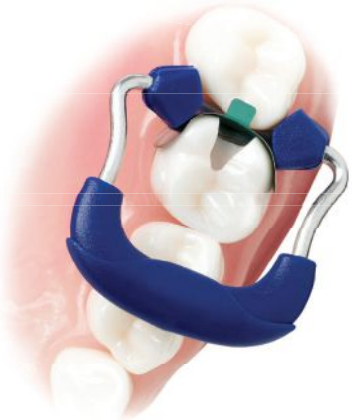

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DENTAL EROSION

Medication-Related Dental Erosion: A Review

Manuel S. Thomas, BDS, MDS; A. R. Vivekananda Pai, BDS, MDS; and Amit Yadav, BDS, MDS

Abstract: Dental erosion has become a major problem that affects the long-term health of the dentition. Among the various potential causes for erosive tooth wear, the different drugs prescribed for patients may be overlooked. Several therapeutic medications can directly or indirectly be associated with dental erosion. It is the responsibility of oral health providers to make both patients and colleagues aware of drugs that may contribute to this condition. Therefore, the purpose of this discussion is to provide an overview of the various therapeutic medications that can be related to tooth erosion. The authors also include precautionary measures—summarized as The 9 Rs—to avoid or at least reduce medication-induced erosion.

LEARNING OBJECTIVES

- list the various therapeutic medications that have the potential to cause dental erosion
- discuss the mechanism by which these medications can result in erosion of dental hard tissue
- explain the precautionary measures necessary for reducing the incidence of dental erosion associated with medications

The surfaces of teeth are in a state of dynamic ion exchange in order to maintain equilibrium between demineralization and remineralization.[1] On one side are factors that disrupt this balance, including acids and unhealthy habits (such as cola swishing and fruit mulling), and on the other side are factors that protect tooth-surface integrity such as fluoride and good quantity and quality of saliva (Figure 1).[2,3] A change in this equilibrium toward the destructive factors can result in tooth-surface loss.[4]

The gradual loss of tooth structure due to acid dissolution and/or chelation without any microbial involvement is referred to as dental erosion.[3] As mentioned above, this non-carious tooth lesion of multifactorial etiology can be a result of the tooth-surface ionic imbalance.[5] The tooth-surface loss can be exacerbated when other conditions like dental attrition or abrasion occur simultaneously with the chemical process.[6] Non-carious loss of tooth structure is shown to be on the rise in the general population due to changes in dietary and behavioral habits.[7]

Sources of the acid that lead to tooth erosion can be either intrinsic (acid content from within the body) or extrinsic (from an external acid source).[5,8] One source of acid that is often overlooked is that of the various medications prescribed by doctors. Some medications

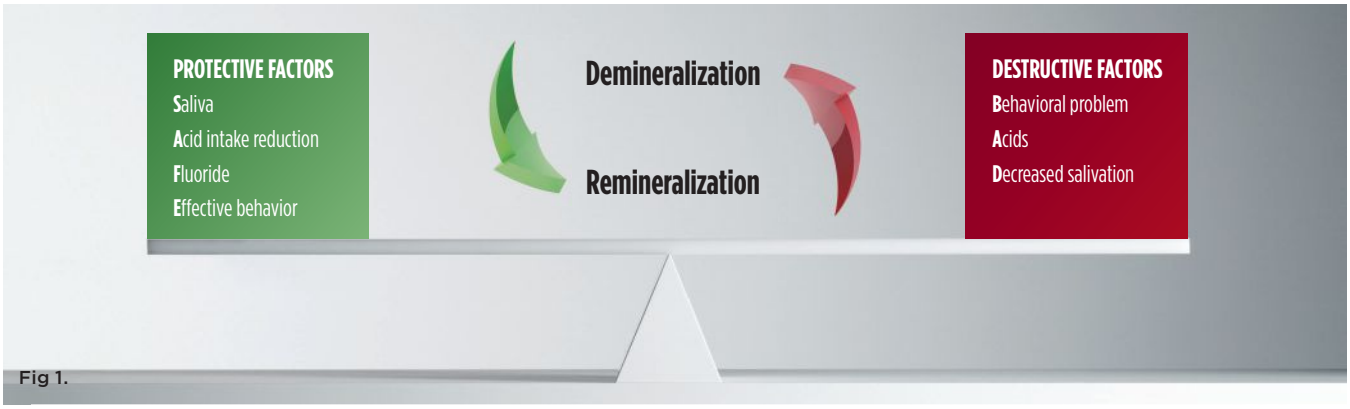

Fig 1. Tooth-surface demineralization and remineralization equilibrium, an analog to the caries "imbalance" described by Featherstone and others.[41]

cause dental erosion directly, as a result of their acidity or chelating action,[9] while others cause erosion of the dental hard tissue secondary to their side effects (Figure 2).[10] Therefore, oral healthcare providers should educate patients and colleagues about the drugs that can cause dental erosion, either directly or indirectly.

Hence, the purpose of this review is to give a broader perspective on the various therapeutic medications that can cause dental erosion. This article also aims to highlight different measures that can be taken to reduce the incidence of such an occurrence.

Direct Association

Medications with a pH of <5.5—which is the critical pH for enamel—may cause dental erosion.[11] Other factors that influence the erosive potential of a substance are its titratable acidity, pKa value, chelation property, mineral content, and the time and frequency of acid contact.[5] Various therapeutic medications or agents have the potential to cause erosive dental lesions due to their inherent acidity. These include the following:

- ***Vitamin C and other oral supplements***: Supplemental vitamin C (L-ascorbic acid) can be dispensed as chewable tablets, syrups, or effervescent tablets.[9] Prolonged use of vitamin C supplements, especially the chewable tablets, has been reported to cause severe dental erosion.[12] Iron tonic and amino-acid supplements (Figure 3), too, have been implicated in tooth erosion.[13]
- ***Aspirin***: Prolonged use of chewable or powdered aspirin (acetylsalicylic acid) for the treatment of chronic pain has been shown to cause dental erosion.[14,15] The contact time of this acidic medication with the teeth is prolonged when using chewable or powdered formulations. This, in turn, increases the risk for dental erosion.
- ***Hydrochloric acid (HCl)***: Preparations containing HCl, dispensed in tablet or liquid form, may be prescribed for patients with certain gastric disorders. These are known to cause erosion of teeth, especially when chewed or swished around, rather than immediately swallowed.[16]
- ***Asthma medications***: Though some investigators revealed no clear association between asthma and dental erosion,[17] various other studies have shown that patients with asthma are at a heightened risk of developing dental erosion.[18-20] The acidic nature of the medications used to control asthma has been implicated as a reason. It has been shown that many asthmatic drugs in current use (eg, beclomethasone dipropionate, fluticasone, salmeterol, and terbutaline sulfate)—especially those delivered in the powdered form—have a pH less than the critical level of 5.5 required for the dissolution of hydroxyapatite.[21] Although a study by Tootla et al[22] demonstrated no clinically significant acidogenic response with the different inhalers tested, a fall in the salivary and plaque pH was seen with a lactose-based dry powder inhaler. Use of these agents multiple

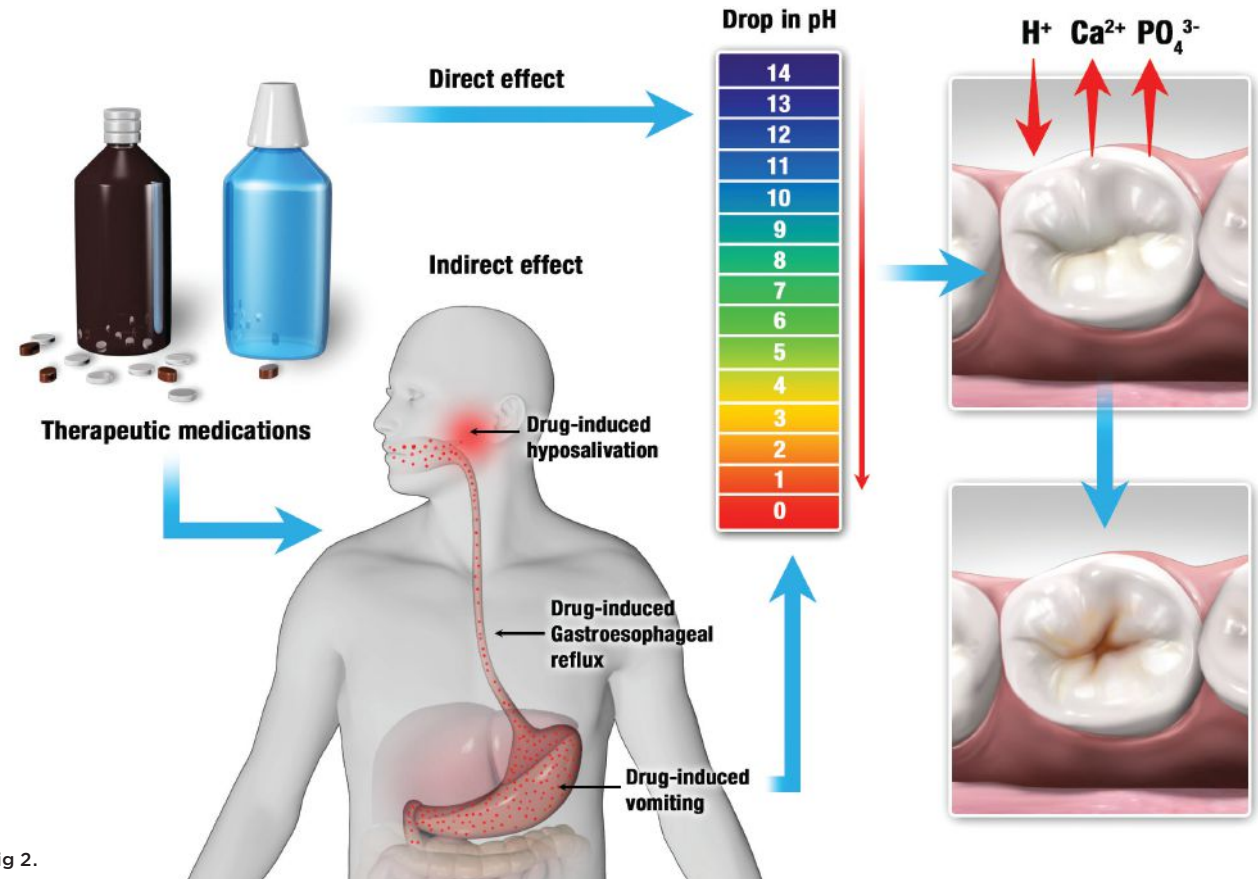

Fig 2.

Fig 2. Mechanism of drug-induced erosion.

times in a day may erode the teeth they contact.[21] The indirect association of asthmatic medications and dental erosion (reduced acid clearance and increased gastric reflux) will be discussed later.

- ***Low-pH mouth rinses***: Some of the proprietary mouth rinses available for purchase by the general public are shown to be acidic.[23] Results of a study that measured the erosive potential of various low-pH mouth rinses indicated that acidified sodium chlorite mouth rinse produced erosion similar to orange juice.[24] In another in vitro study, an EDTA-containing anti-calculus rinsing solution exhibited dissolution of enamel after 2 hours of exposure due to the calcium-chelating action of EDTA.[25] An essential-oil mouthwash (Listerine®, Johnson & Johnson, www.listerine.com) was shown in a longitudinal in vitro study using quantitative light-induced fluorescence to cause erosion compared to the negative control, but this was only significant after 14 hours of continuous use.[26] This suggests that prolonged use of these low-pH oral rinses has the potential to cause dental erosion.
- ***Liquid medications/pediatric syrups***: Numerous liquid oral medications/pediatric syrups prescribed by physicians have been shown to be acidic.[27] When these acidic liquid medications are consumed for prolonged periods, as seen in cases of chronic diseases, they can cause dental erosive lesions.[28] Acids—commonly citric acid—are in these medications for various reasons, including to maintain chemical stability, to control tonicity, to ensure physiological compatibility, and to improve flavor for patient acceptance.[29]
- ***Medications available in effervescent/dispersible form***: It has also been proposed that effervescent/dispersible tablets cause erosive tooth lesions, primarily due to their use of extra acid to promote the acid-based reactions that act to disperse effervescent and dispersible tablets on contact with water.[27]
- ***Acidic salivary substitutes/salivary flow stimulants***: Patients suffering from xerostomia may be advised to use either salivary flow stimulants or salivary substitutes. Salivary flow stimulants and artificial saliva with low pH and high titratable acidity can lead to dental hard tissue demineralization, especially in patients with reduced salivary protection.[30]
- ***Bleaching agents***: Some bleaching agents available in the market have an acidic pH. This is mainly to avoid their degradation and thereby increase storage time. It was observed in an in vitro study that acidic bleaching agents resulted in significantly higher enamel hardness loss when compared to less acidic agents.[31] The presence of saliva can eliminate the demineralization effect caused by low pH.[32] Therefore, it is important to consider the bleaching agent's pH and composition, especially when treating patients with reduced salivary secretion.[33]

Indirect Association

The medications that have the potential to cause erosion of the dental hard tissue secondary to their side effects are mentioned below:

- ***Drug-induced hyposalivation:*** Saliva plays an essential role in preserving the surface integrity of dental hard tissues. The protective role of saliva against dental erosion can be attributed to the following factors:[34,35]
  - Dilution and clearance of erosive agents from the oral cavity
  - Buffering and neutralization of acids
  - Reduction of demineralization and enhancement of remineralization by the presence of calcium, phosphate, and fluoride ions
  - Formation of a protective diffusion barrier (acquired pellicle) on the tooth surface

Therefore, the medications that cause reduced salivary flow can put the patient at risk of tooth erosion by reducing the protective function of saliva against extrinsic as well as intrinsic acids (Figure 4). Some of the drugs associated with reduced salivation are alpha-receptor antagonists; anticholinergics; antidepressants (eg, serotonin agonists or noradrenaline and/or serotonin re-uptake blockers); antipsychotics such as phenothiazines; atropinics; muscarinic receptor antagonists; HIV protease inhibitors; and antiasthmatic agents (beta-2 adrenoceptor agonists).[10] An article on drug-induced dry mouth by Scully[36] is a useful resource for additional details.

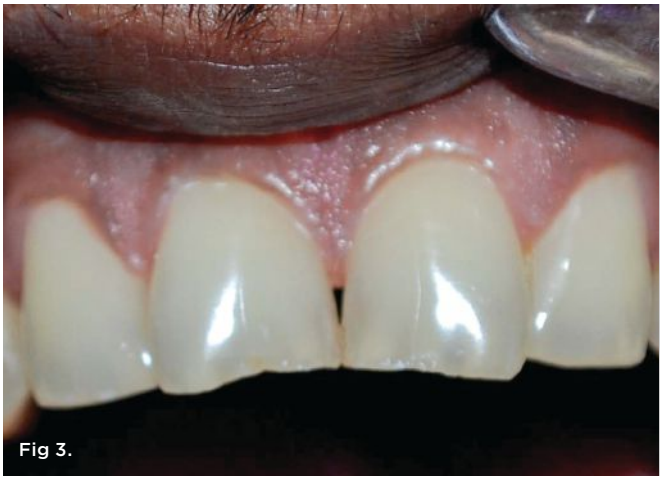
Fig 3.

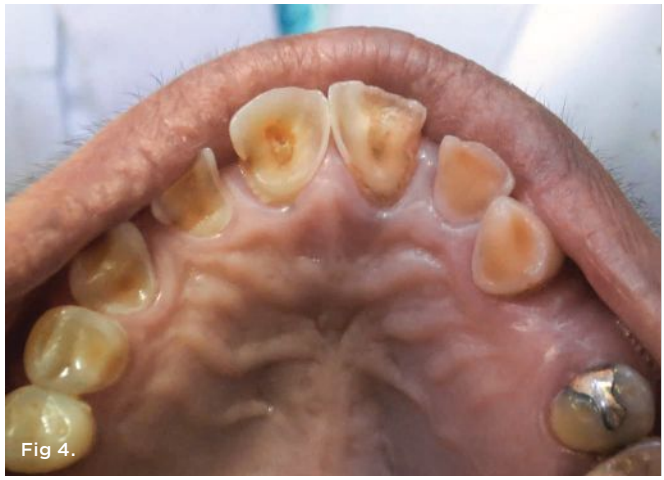
Fig 4.

Fig 3. Dental erosion caused by chewable amino acid supplements in a 30-year-old body builder. **Fig 4.** Erosion secondary to hyposalivation caused by antiasthmatics and antihypertensive drugs in a 76-year-old female patient.

- ***Drug-induced gastroesophageal reflux:*** Drugs likely to cause gastroesophageal reflux disease can cause the intrinsic gastric acid to reach the oral cavity and thus increase the risk for dental erosion.[10] Some examples of such medications include antispasmodic drugs (theophylline), antiasthmatic medications, anticholinergics, progesterone, and calcium channel blockers. For more information, refer to the article by Bartlett and Smith.[37]
- ***Drug-induced vomiting:*** Drugs that induce vomiting can also be considered an indirect cause of dental erosion. For example, abuse of ipecac syrup (an over-the-counter emetic) by bulimics can result in dental erosion. Similarly, patients undergoing cytotoxic chemotherapeutic drug treatment for malignancies may suffer from frequent vomiting, resulting in erosion. Thus, extended use of such drugs can cause dental erosion as a secondary side effect.

Prevention and Management

Various measures to prevent and reduce the incidence of dental

TABLE 1

The 9 Rs in the Management of Dental Erosion

9 RS	EROSIVE PROTECTION MEASURES[8,38-40]
Recognize early	• Early detection and monitoring should be emphasized.
Reduce acid contact	• Chewable and effervescent formulations should be avoided, especially when experiencing drug-induced xerostomia. • Acidic mouthwashes should be avoided, especially by individuals with hyposalivation. • A spacer device should be used to deliver inhaled drugs directly to the airway. • A protective mouthguard should be used.
Remove the acidic challenge	• Acidity can be neutralized directly with the use of fluoride mouth rinse/sodium bicarbonate solution/milk or food such as cheese or sugar-free yogurt. If none of the above is feasible, the mouth should be rinsed with water. • Salivary flow can be stimulated with non-acidic lozenges.
Resist acid dissolution	• Tooth surfaces can be made resistant to acid impact either by applying dentin adhesive or fluoride or by using amorphous calcium phosphate-casein phosphopeptide.
Recommend healthy behavior	• Low-pH mouth rinse should not be used beyond the short term and should never be used before brushing. • Use of a soft toothbrush and low-abrasion fluoridated toothpaste is recommended. • Brushing should be postponed for at least 1 hour after the consumption of acidic/erosive food. • An acid challenge immediately after brushing should also be avoided. • Acidic liquid medications should not be sipped, held in the mouth, or swished in the mouth. • When possible, tablets should be chosen over liquid medications. • Patients should be urged to drink water frequently to counteract dry mouth.
Refer if needed	• Refer to a gastroenterologist to exclude gastrointestinal disease. • Dentists should be aware of the drugs that can cause dental erosion and educate colleagues and medical practitioners to take the necessary precaution when prescribing these medications.
Regulate formulations	• Manufacturers can modify formulations by increasing the calcium, phosphate, and mineral content in the medication and, if possible, use formulations with low titratable acidity as substitutes. • Manufacturers should provide consumers with sufficient information regarding the erosive potential of various medications.
Regular checkups	• Dentists should encourage regular dental checkups. • Dentists should educate patients taking medications that can induce erosion directly or indirectly about their susceptibility to oral health problems.
Rehabilitate	• Dentin hypersensitivity should be managed appropriately. • Esthetic rehabilitation should be addressed. • Functional rehabilitation should be addressed.

erosion related to medications have been summarized in Table 1 as The 9 Rs in the management of dental erosion.

Conclusion

Various medications can either directly or indirectly be implicated as causative factors in the etiopathogenesis of tooth erosion. It is the responsibility of dental professionals to educate patients and medical practitioners about the different precautions that can be taken to prevent and control therapeutic medication–related dental erosion.

DISCLOSURE

The authors had no disclosures to report.

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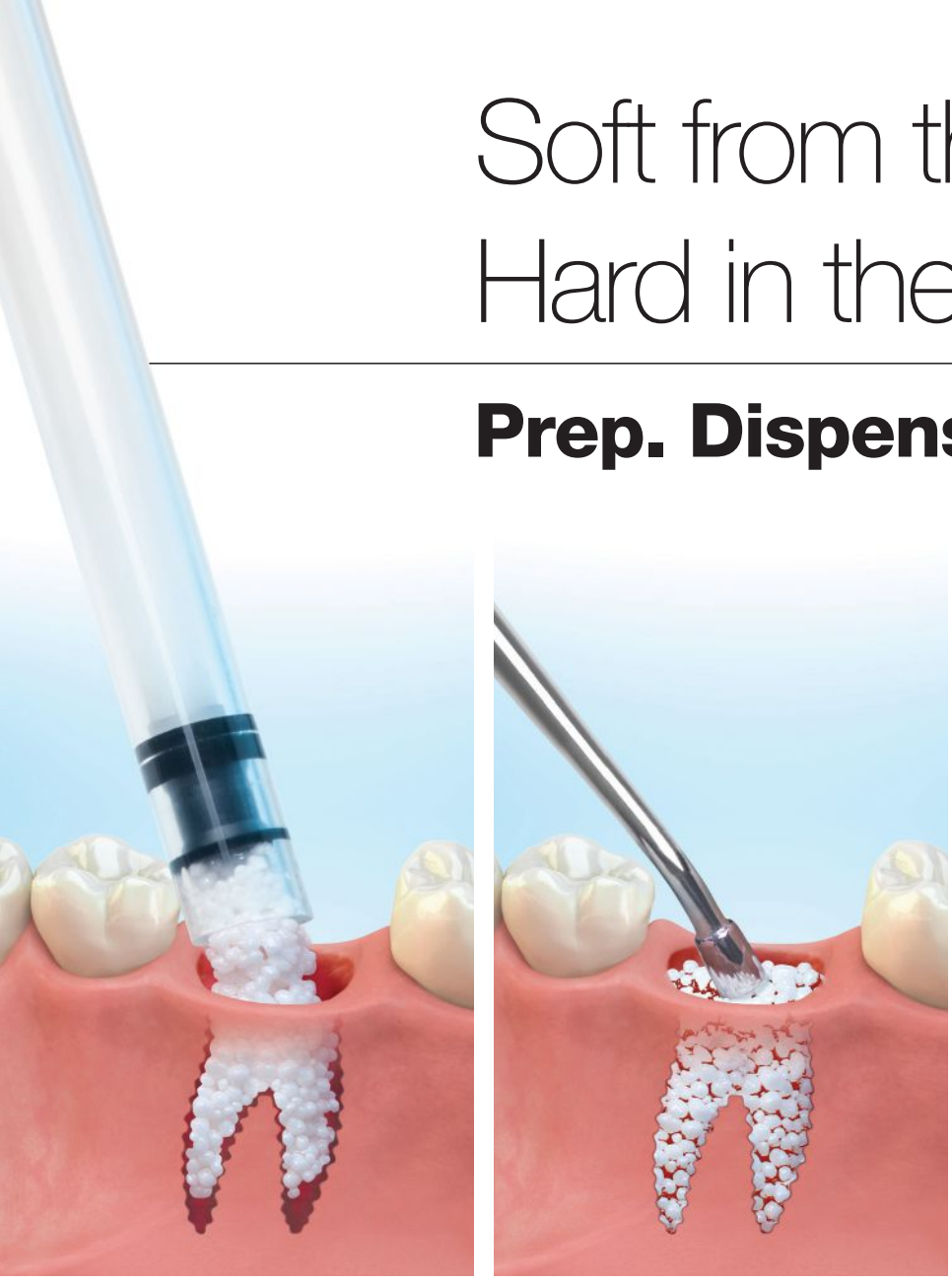

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Medication-Related Dental Erosion: A Review

Manuel S. Thomas, BDS, MDS; A. R. Vivekananda Pai, BDS, MDS; and Amit Yadav, BDS, MDS

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1. **The gradual loss of tooth structure due to acid dissolution and/or chelation without any microbial involvement is referred to as dental:**
   A. erosion.
   B. abrasion.
   C. abfraction.
   D. attrition.

2. **One source of acid that is often overlooked is that of:**
   A. fruits.
   B. vegetables.
   C. stomach acid.
   D. the various medications prescribed by doctors.

3. **The critical pH for enamel is:**
   A. 7.5.
   B. 6.5.
   C. 5.5.
   D. 4.5.

4. **Regarding aspirin, the contact time of this acidic medication with the teeth is what when using chewable or powdered formulations?**
   A. reduced
   B. prolonged
   C. multiplied
   D. decreased

5. **Preparations containing hydrochloric acid, dispensed in tablet or liquid form, may be prescribed for patients with:**
   A. diabetes.
   B. certain gastric disorders.
   C. hypertension.
   D. neuropsychiatric diseases.

6. **Many asthmatic drugs in current use, especially those delivered in the powdered form:**
   A. will cause decreased salivary flow and therefore secondary erosion.
   B. will cause increased salivary flow and therefore secondary erosion.
   C. have a pH less than the critical level required for the dissolution of hydroxyapatite.
   D. decrease the salivary pellicle thickness.

7. **Acids are in liquid medications and pediatric syrups for various reasons, including to:**
   A. maintain chemical stability.
   B. control tonicity and ensure physiological compatibility.
   C. improve flavor for patient acceptance.
   D. all of the above

8. **Some bleaching agents available in the market have an acidic pH. This is mainly to:**
   A. reduce the bad taste often associated with bleaching.
   B. increase the speed of bleaching.
   C. avoid their degradation and thereby increase storage time.
   D. decrease the quantity of material required for bleaching and, therefore, the cost.

9. **The medications that cause reduced salivary flow can put the patient at risk of tooth erosion by:**
   A. reducing the protective function of saliva against extrinsic as well as intrinsic acids.
   B. changing how sodium ions are buffered.
   C. changing how phosphate ions are buffered.
   D. changing how fluoride ions are buffered.

10. **Drugs that induce vomiting can also be considered:**
    A. a primary source of dental erosion.
    B. an indirect cause of dental erosion.
    C. the major cause of dental erosion by a factor of 10.
    D. the major cause of dental erosion by a factor of 100.

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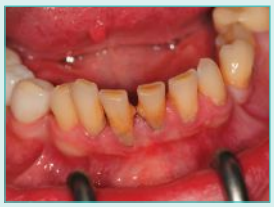
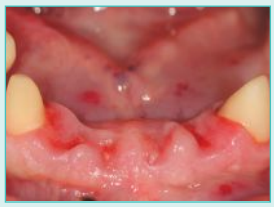
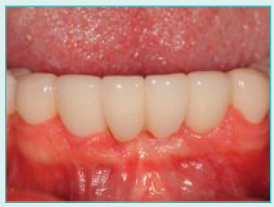


Before implant placement.

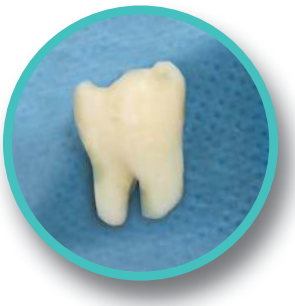


Ready for implants 10 weeks after extraction and grafting.



12 weeks after implant placement.

▶ **Extract**



▶ **Grind**

▶ **Graft**

*Binderman et al., Journal of Interdisciplinary Medicine and Dental Science 2014, 2.6

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OCCLUSAL DIAGNOSIS AND TREATMENT

Occlusal Diagnosis and Treatment Provide the Foundation for Successful Restorative and Esthetic Treatment

John Scalas, DDS

Abstract: This case demonstrates how a patient whose initial complaint was lower anterior crowding achieved improved function and prognosis for her dentition through treatment for her occlusion. Although she had initially refused the recommended orthodonture in favor of the compromise approach of composite restoration and enamoplasty, she ultimately proceeded with the orthodonture after completion of treatment for caries and defective maxillary restorations. Her overall prognosis improved because the maxillary anterior teeth were restored to harmonious proportions and length and her mandibular anteriors were no longer visibly crowded and rotated. Prognosis also improved because occlusion was improved.

A 37-year-old woman who had been in the practice since childhood expressed interest in improving the appearance of her front teeth (Figure 1). Her main concern was lower anterior crowding. She had no history of orthodontic treatment. Her medical history was non-remarkable, and she was classified as ASA1.

The patient's dental history included a recent history of cracked teeth and a complaint that her teeth seem to be getting shorter (Figure 2). She also reported that she had "more than one bite," and felt that the lower anterior crowding seemed to be getting worse. She had whitened her teeth with no adverse effects.

Diagnosis, Risk Assessment, and Prognosis

Periodontal: This patient had maintained a very consistent schedule of 6-month recalls since childhood. There were several 4-mm pockets in the posterior, with all other areas measuring 3

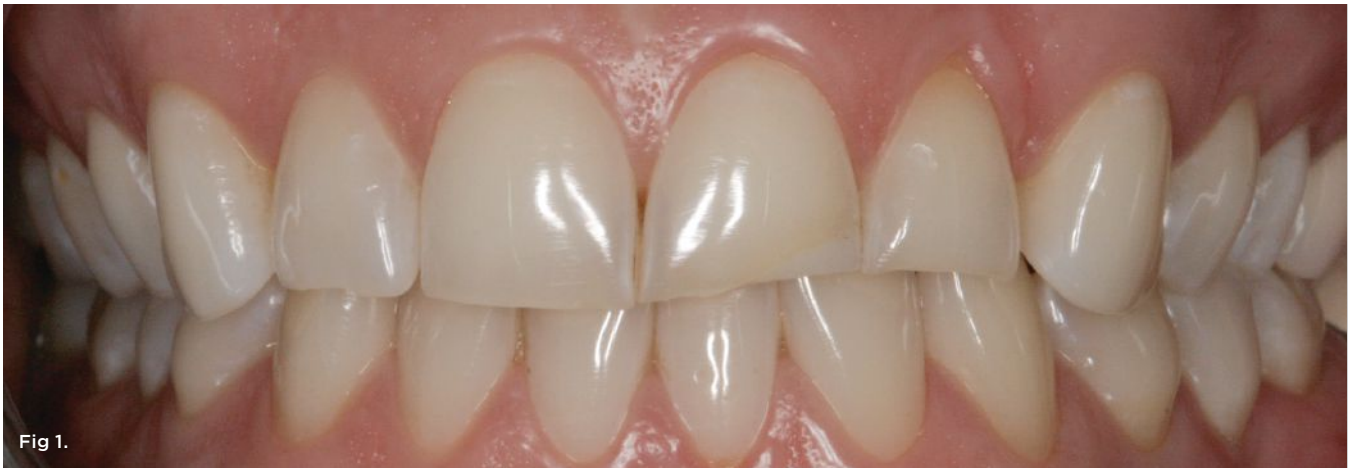

Fig 1. A preoperative photograph shows the wear on the maxillary incisors and lower anterior crowding.

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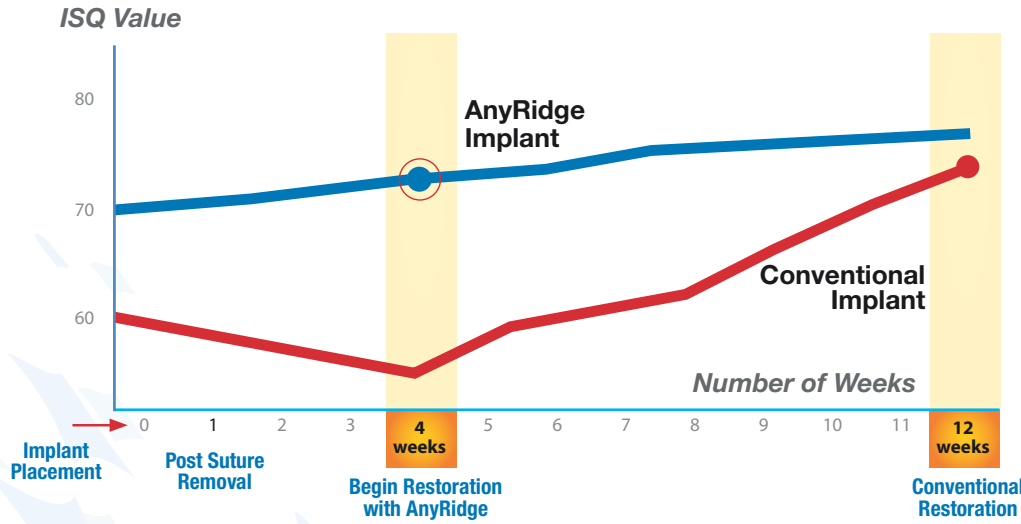

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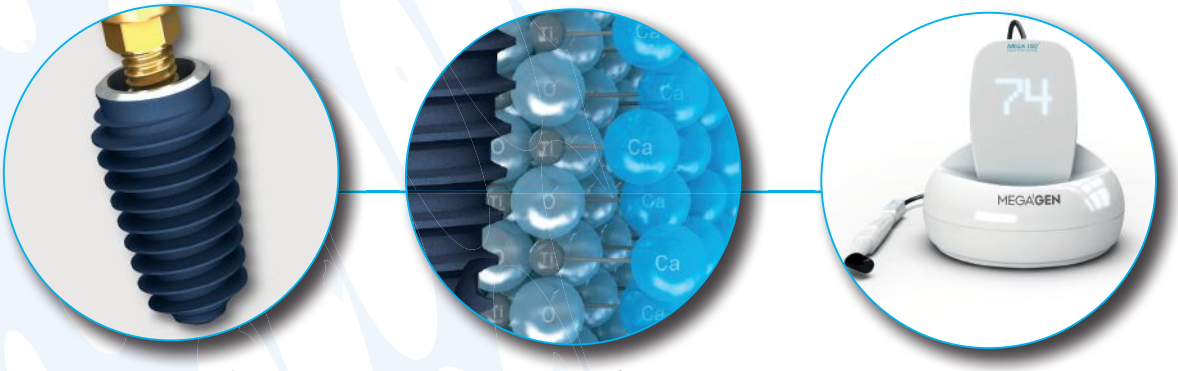

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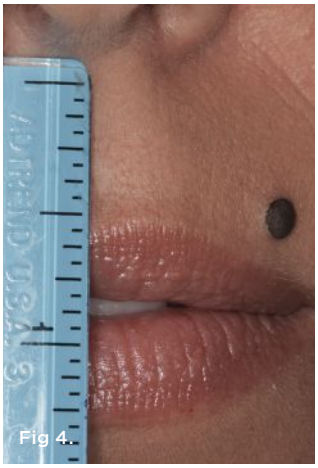
Fig 2.


Fig 3.

Fig 2. A preoperative photograph with the lips in repose. **Fig 3.** A preoperative photograph with full smile. **Fig 4.** Central incisor display measured with the lips in repose. **Fig 5.** Central incisor display measured during a full smile.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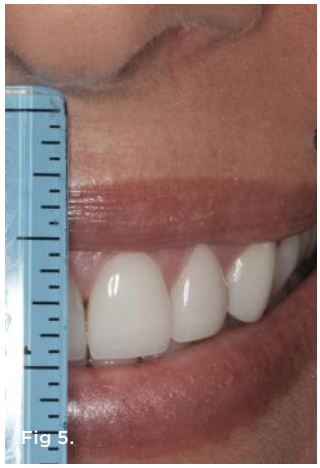
Fig 5.

mm or less. No bone loss of greater than 2 mm was evident on the full-mouth radiographic series. No evidence of mobility was noted. Tooth No. 10 had a 1-mm area of recession. She was determined to have AAP Type 2 mild adult periodontitis.
Risk: Low
Prognosis: Good

Biomechanical: Tooth No. 3 had a defective distal-occlusal-lingual onlay and active caries on the mesial. Tooth No. 30 had an enamel lesion on the mesial that radiographically did not appear to have penetrated the dento-enamel junction. When prior radiographs were reviewed, it was noted that the appearance was unchanged over time. Teeth Nos. 3, 14, and 18 were deemed to be at risk for future endodontic treatment due to the presence of full-coverage restorations on teeth Nos. 14 and 18 and the large defective restoration, and caries on tooth No. 3. Tooth No. 15 had a questionable occlusal composite restoration. Incisal erosion was evident on teeth Nos. 7 through 10 and 23 through 26. Attrition was evident on teeth Nos. 7, 9, and 10. Teeth Nos. 9 and 10 had been restored 19 years previously after an accident, and the restorative material also displayed attrition.
Risk: Moderate
Prognosis: Generally fair; hopeless for tooth No. 3 without caries treatment

Functional: The patient reported "having more than one bite" on the dental history evaluation. She reported no TMJ symptoms, and the clinical evaluation of the temporomandibular joints revealed no pain, soreness, or joint sounds. The load and immobility tests were normal and her opening was 54 mm with no deviation. Abnormal attrition was noted on teeth Nos. 7, 9, and 10. After wearing an anterior deprogrammer, the point of initial contact was on posterior teeth Nos. 2 and 31, confirming the diagnosis of occlusal dysfunction.
Risk: Moderate
Prognosis: Fair

Dentofacial: With an unguarded smile, the patient had bilateral display of her teeth, gingiva, and interdental papillae posteriorly to the first molar (Figure 3). She also showed approximately half of her lower incisors with a wide "eee" smile. In repose, the maxillary canines were at a 0 position relative to the resting lip, and the movement of her upper lip when she smiled was hypermobile (Figure 4 and Figure 5).
Risk: High
Prognosis: Fair

Treatment Plan Presentation and Informed Consent

At the treatment plan presentation, the patient agreed to treatment to restore the proper length of the upper incisors, but she rejected orthodontic treatment to address the lower anterior crowding. She also accepted treatment of the four maxillary incisors after viewing a laboratory wax-up and understanding the esthetic outcome that could be achieved with porcelain veneers. An alternative proposal was offered to mask the mandibular crowding with enamoplasty and direct composite restorations for the lower incisors. She was informed

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that this was a compromise relative to orthodontic treatment, and she agreed to complete the maxillary restorative treatment prior to the enamoplasty of the lower incisors.

Treatment Goals

The following specific measures were established as treatment goals:

- Treat the occlusal dysfunction with equilibration, and avoid creating a constricted chewing pattern after the equilibration.
- Treat the caries and defective restoration on tooth No. 3 with an indirect porcelain onlay.
- Restore the appropriate incisal length of teeth Nos. 7 through 10 with feldspathic porcelain veneers.
- Close the space between teeth Nos. 10 and 11 while maintaining harmonious mesiodistal proportions with direct composite bonding on the mesial of tooth No. 11.
- Resolve lower anterior crowding orthodontically. (The patient initially refused this treatment, but she changed her mind after the veneer treatment was completed.)
- Maintain periodontal health with a continued 6-month recare schedule.
- Provide instruction to maximize potential for continued stability of the arrested lesion on tooth No. 30.

> The functional risk was lowered from moderate to low and she now has stable, acceptable function. The occlusal equilibration addressed the diagnosis of occlusal dysfunction.

Treatment Sequence

Phase 1—Establishment of Centric Relation

Prior to any restorative care, the patient wore a Kois deprogrammer[1] (Figure 6). Once the deprogramming was confirmed, the models were mounted in centric relation (CR).

A trial equilibration was performed on the mounted models to verify that the equilibration could be performed without undue tooth structure removal and without causing a constriction in the anterior. The occlusal equilibration was then completed intraorally to an acceptable endpoint with simultaneous bilateral equal contact in the posterior teeth and no anterior contact in the envelope of function.

Phase 2—Models Created, Mounted in MIP, and Evaluated

After the equilibration was completed, new alginate impressions were made, and then poured in stone for mounting, esthetic evaluation, and wax-up. The stone models were inspected for any distortions and trimmed for mounting. A facebow record was taken with the Kois Dento-Facial Analyzer System (Panadent, www.panadent.com) to accurately position the maxillary cast on the articulator with the platform and incisal pin set at 0 (Figure 7). The maxillary cast was then mounted onto the articulator using the removable plate

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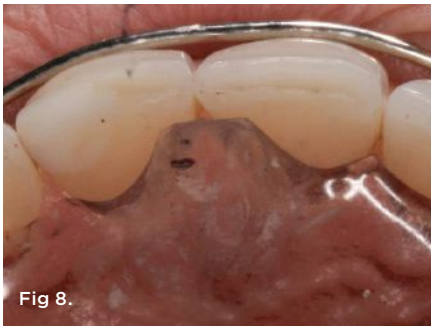
from the facebow (Figure 8). Because the patient's occlusal dysfunction was successfully treated with the occlusal equilibration, the models could be mounted in maximum intercuspal position (MIP), which after treatment to an acceptable function was coincident with CR.[2,3]

After evaluation of the mounted models, it was decided that tooth No. 8 was at the appropriate incisal length[4] (Figure 9). If it had been determined that a different incisal length was necessary, the articulator platform could have been moved to the appropriate position with the wax-up, then guided by the platform position. In this case, the wax-up was done to the desired length by simply waxing to the zeroed platform and incisal pin (Figure 10). Teeth Nos. 7 through 10 were waxed up to give pleasant symmetry to the provisional and final restorations. Serving as a model for final restorations, the wax-up was used to fabricate Luxatemp® (DMG, www.dmg-dental.com) provisional restorations for an esthetic and functional trial.

Phase 3—Restoration Placement

After the diagnosis and treatment plan was completed using standard protocols, an enamel- supported mesio-occlusal-distal-lingual feldspathic porcelain onlay was placed to treat the carious lesion and defective existing restoration. Feldspathic porcelain veneers were placed on teeth Nos. 7 through 10 using standard protocols, and a small direct composite restoration was bonded to the mesial of tooth No. 11 to maintain the correct size proportions of the maxillary anterior teeth. Because the canines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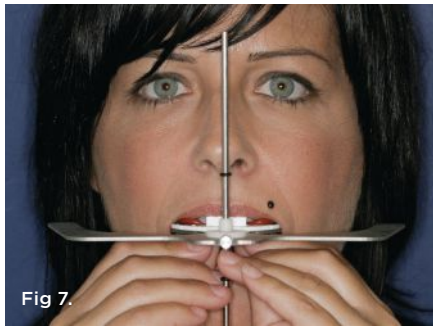
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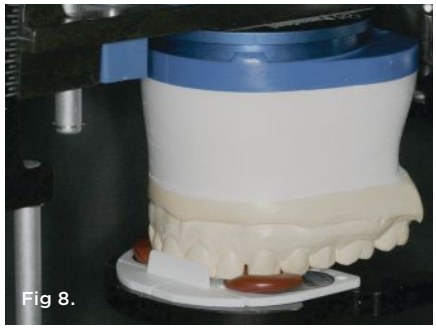
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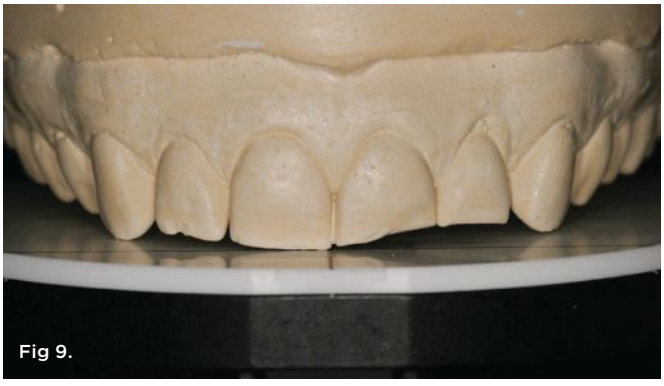
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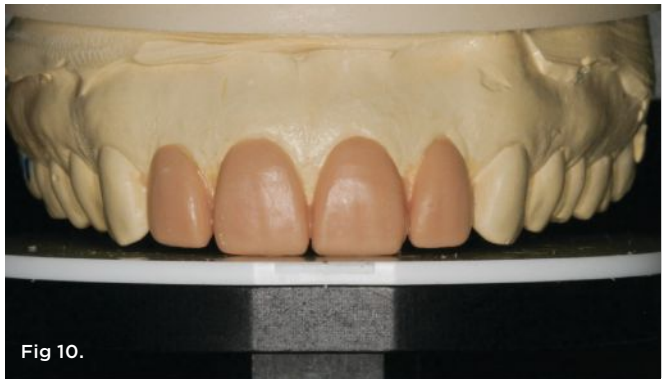
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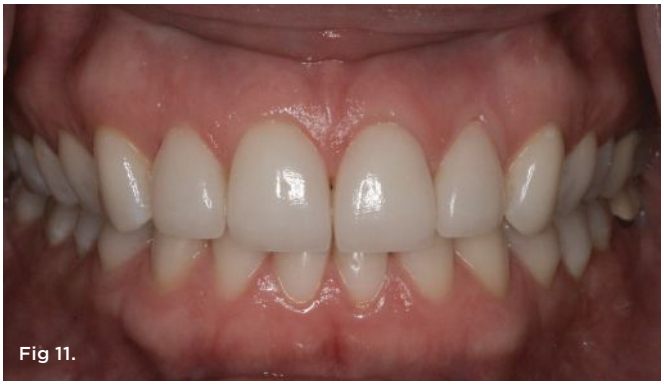
Fig 11.

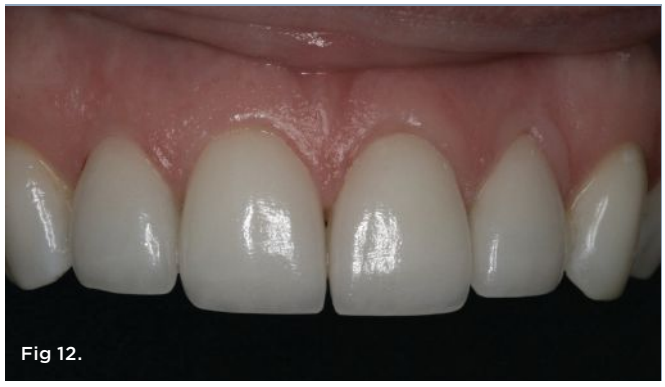
Fig 12.

Fig 6. Articulating paper markings on the Kois deprogrammer showing a repeated closing position. **Fig 7.** The facebow recording captures the maxillary occlusal plane. **Fig 8.** The initial preoperative mounting of study models showing the incisors touching the vertical platform, as they were in the mouth. **Fig 9.** Analysis of the mounted preoperative study models reveals uneven incisal edges. **Fig 10.** After the selection of the mesio-incisal edge of tooth No. 8 as the correct incisal position, teeth Nos. 7 through 10 are waxed to the platform. **Fig 11.** A close-up view of the completed porcelain veneers on teeth Nos. 7 through 10. **Fig 12.** The completed case in a retracted view.

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were not involved in the treatment plan, the acceptable function established previously with the occlusal equilibration was not compromised or altered. A satisfactory esthetic and occlusal result was obtained (Figure 11).

Phase 4—Orthodonture

After the veneer treatment was finished, the patient decided that she did indeed want to have limited orthodontic treatment to resolve the lower anterior crowding. Referral to an orthodontist and a short course of limited orthodontics quickly and conservatively addressed the patient's presenting concern.

Discussion and Conclusion

While initially reluctant to pursue orthodontics to solve her chief concern, the patient was willing to address her maxillary teeth. Once this treatment was completed, she opted for correct positioning of her lower anterior teeth instead of the compromise approach[4] enamoplasty. She had an excellent result (Figure 12). Her periodontal risk remains low, with a good prognosis, and she remains on a 6-month recall.

Biomechanically, the prognosis was improved from hopeless to fair for tooth No. 3 because active caries were treated. Enamel surface management for the arrested lesion on tooth No. 30 included patient education to minimize risk of lesion progression. Enamel-supported veneers on teeth Nos. 7 through 10 did not substantially increase the risk to these teeth.

The functional risk was lowered from moderate to low and she now has stable, acceptable function. The occlusal equilibration successfully addressed the diagnosis of occlusal dysfunction. She now reports stable function. The position of the anterior teeth does not impinge on the envelope of function. By addressing the occlusion first, all treatment provided continued to maintain acceptable function throughout the restoration and orthodonture in both arches. The patient was extremely happy with all of her definitive restorations and that her lower anterior crowding was successfully treated with orthodontics.

The patient's dentofacial risk remained unchanged, as no treatment (Botox, lip lengthening) was provided to address the amount of gingival display due to her high lip line. The patient expressed no concerns, either preoperative or postoperative, about the gingival display when she smiled. Her prognosis did improve because the maxillary anterior teeth were restored to harmonious proportions and length, and her mandibular anteriors were no longer visibly crowded and rotated (Figure 13 and Figure 14).

ACKNOWLEDGMENTS

The author would like to thank Erik Southers, DDS, for providing the orthodontic care in this case, and Nelson Rego, CDT, for his expert lab work.

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Fig 13.


Fig 14.

Fig 13. Postoperative photograph with the lips in repose. **Fig 14.** Postoperative photograph with the patient in a full smile.

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The Teamwork Approach to Esthetic Tooth Replacement with Immediate Implant Placement and Immediate Temporization

Barry P. Levin, DMD; and Brian L. Wilk, DMD

Abstract: Enduring a period of edentulism between extraction and final restoration is difficult for patients—especially when it concerns the esthetic zone. The approach described demonstrates key points of consideration when replacing a maxillary anterior tooth with a dental implant using immediate implant placement, hard- and soft-tissue augmentation, and provisionalization. The authors stress adherence to patient selection and prosthetic design guidelines, and recommend the use of a digital impression technique, rather than traditional, rubber-based impressions.

The challenge of replacing a tooth in esthetically sensitive areas is exacerbated during the period between extraction and delivery of the definitive restoration. When implants can be placed into the extraction socket immediately after extraction, the treatment period is shortened compared to delayed protocols. Regardless of the advantages of immediate placement, some period of edentulism is frequently endured by the patient. Provisionalization of immediate implants can circumvent this problem. In a case series, Norton[1] showed the predictability of immediate temporization in the esthetic zone in terms of stable peri-implant bone levels up to 9 years after therapy. The current authors[2] demonstrated the success of immediate placement and temporization in terms of bone maintenance at 12 months loading with the final restoration.

One of the other advantages of this technique is the conditioning of soft tissues from the outset of treatment. Becker et al[3] demonstrated how provisionalization of immediate implants can develop favorable emergence profiles prior to fabrication of the final restoration. Relative to conventionally loaded implants, Shibly et al[4] demonstrated comparable success with immediately loaded implants in a clinical study.

In a 1-year study, Cosyn et al[5] demonstrated the success of immediate implant placement and screw-retained temporization. Of note, they treated patients with thick periodontal biotypes and treated sites with postoperative recession with subepithelial connective tissue grafts. Other clinicians have found that routine placement of these autogenous tissue grafts results in more favorable esthetics compared to treatment without these grafts.[6] Others have used autogenous bone grafts from distant sites to support facial soft tissues in compromised sites.[7]

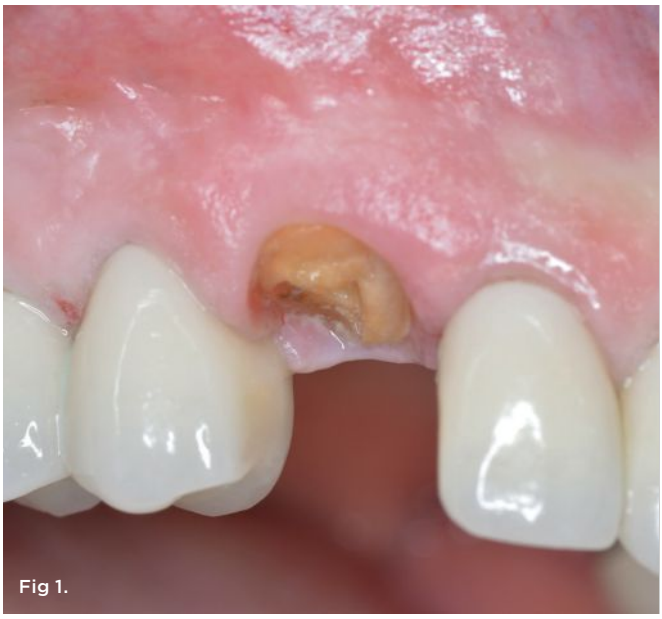
In a case series, Valentini et al[8] showed how immediate implant placement and simultaneous bone regeneration (bone xenograft and collagen membrane) can be successfully implemented with temporization at the time of implant placement.

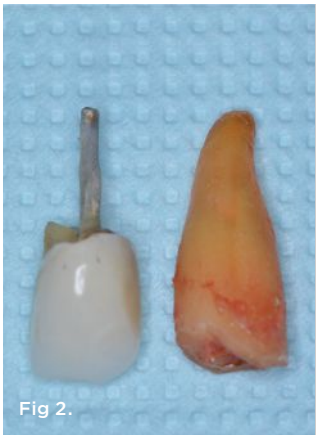
At present, there is no consensus as to the most favorable method of preserving or augmenting peri-implant hard and soft tissues in these types of procedures. Regardless of how these sites are managed, some attempt at tissue preservation is recommended by the authors to avoid long-term esthetic complications.

The purpose of this case report is to demonstrate key points of consideration when replacing a maxillary anterior tooth with a dental implant. Implant timing, selection, method of placement, and management of hard and soft tissues are paramount to achieving success. Additionally, the method and timing of temporization, incorporation of technologies, and restoration are equally crucial to achieving a long-term, esthetic outcome.

Case Report

A 60-year-old man presented to his restorative dentist on an emergency basis with a fractured maxillary right canine (Figure 1). He had a history of periodontal, endodontic, and implant therapy, and had a heavily restored dentition with multiple fixed, tooth-supported,





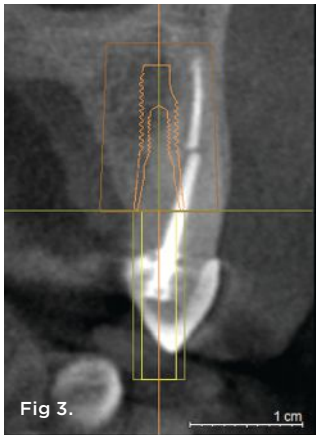


Fig 1. The endodontically treated root of tooth No. 6, which was free of inflammation after fracture of the coronal tooth structure retained with the restorative post and PFM crown. **Fig 2.** Extraction of the root of No. 6 adjacent to the PFM crown containing the prepared tooth structure and post. **Fig 3.** Cross-sectional image of tooth No. 6 obtained from a CBCT scan (GALILEOS, Sirona, www.sirona.com) taken several months earlier to facilitate implant placement in the maxillary posterior sextants. A Kan class I root position is noted for tooth No. 6, with proximity to the facial bone and substantial palatal bone available palatal and apical to the root. Primary stability can be anticipated in favorable situations such as the one depicted in this image.

and implant-supported restorations. A portion of the prepared clinical crown, along with the prosthetic post, was attached to the porcelain-fused-to-metal crown (Figure 2). As a temporary measure, the post was recemented for esthetic purposes until surgical therapy could be initiated.

He presented to his periodontist's office for extraction and implant therapy several days after his crown was recemented. Evaluation of his cone beam computed tomography (CBCT) scan revealed adequate apical and palatal bone to anticipate primary stability of an immediate implant (Figure 3).

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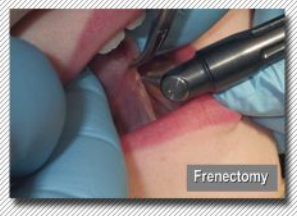

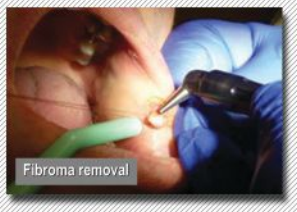

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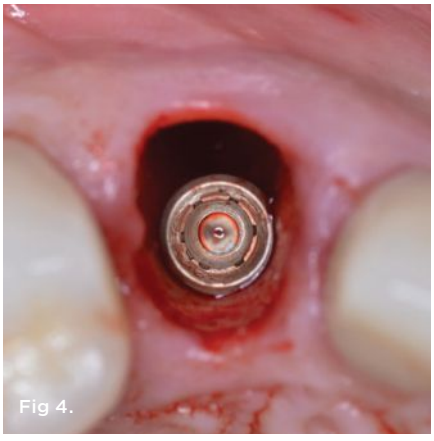
Tooth No. 6 was extracted with care to preserve the thin, intact facial bone and integrity of the surrounding hard and soft tissues. After thorough debridement of the alveolus with ultrasonic and manual instrumentation, the socket was conditioned with a mixture of doxycycline and sterile saline. Once the alveolus was visually clear of soft-tissue remnants, a 13-mm-long implant with a longitudinal diameter of 3.6 mm and a conical portion coronally of 4.2 mm (4.2C x 13 mm [ASTRA TECH Implant System EV™; DENTSPLY Implants, www.dentsplyimplants.com]) was palatally positioned (Figure 4).

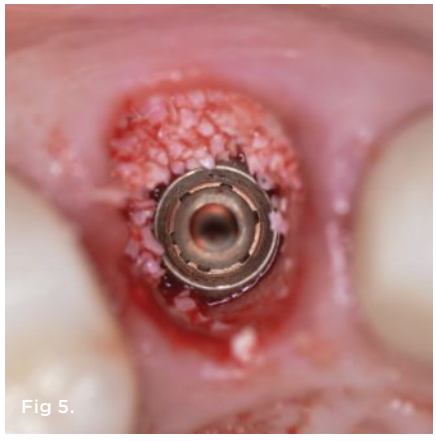
The implant was intentionally positioned palatally, avoiding contact with the thin facial bone, which consists almost entirely of bundle bone. The void between the facial implant surface and facial plate was obturated with a composite graft of mineralized bone allograft (SYMBIOS® Mineralized Cortical Powder, DENTSPLY Implants) and deproteinized bovine bone mineral (Bio-Oss®; Geistlich Pharma North America, www.geistlich-na.com) in a ratio of approximately 4:1 (Figure 5).

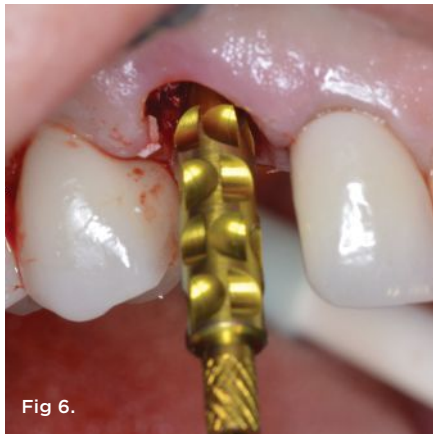
The xenograft was for an osteoconductive, though non-resorbing and space-maintaining, purpose. The graft material was placed level or slightly coronal to the fixture head.

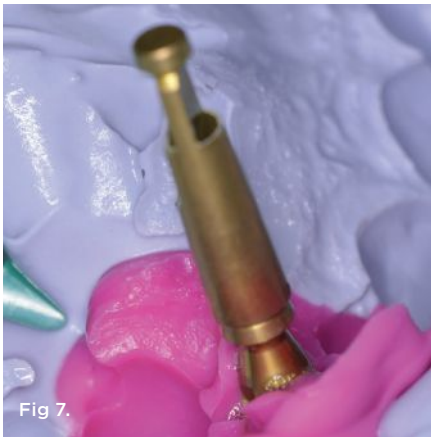
A pick-up impression coping was fastened to the implant (Figure 6), and an open-tray impression (Position™ Penta™ Quick, 3M ESPE, www.3mespe.com) was taken; then an implant replica was attached (Figure 7), and the model was poured immediately. Digital scanning at the time of surgery was not indicated, as immediate temporization would not be possible. A core file would require fabrication, and laboratory steps would delay placement of a temporary restoration for several days.

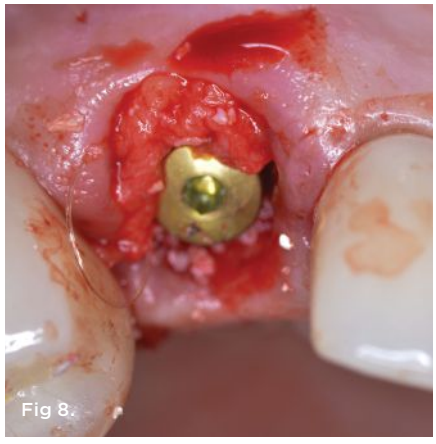
After the impression was obtained, the site was confirmed to be free of any impression material. After removal of the impression coping and tray, the site was inspected, and additional bone graft particulate was added at the desired level of the top of the implant fixture to compensate for any material lost secondary to taking the impression. A subepithelial connective tissue graft was harvested











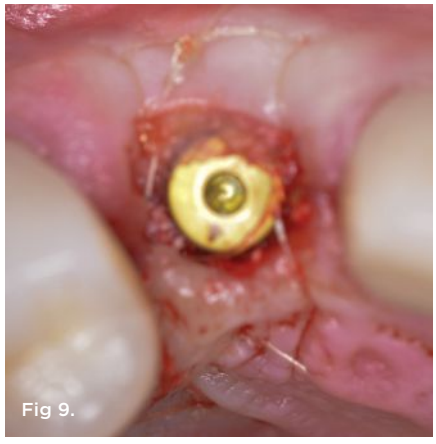


Fig 4. Palatal positioning of the implant, maintaining space between the implant surface and facial cortex, is performed. The fixture top is at least 1.5 mm from the adjacent teeth and 3 mm to 4 mm apical to the gingival margin. **Fig 5.** The void between the implant and walls of the extraction socket is obturated with a composite graft of freeze-dried bone allograft and deproteinized bovine bone mineral. The allograft bone is osteoconductive and can be expected to be replaced with viable bone during physiologic socket remodeling. **Fig 6.** A long pick-up impression coping is attached to the implant after application of the particulate bone graft. **Fig 7.** A rubber-based impression is obtained and an implant replica is attached to the coping prior to pouring a "working model" used to fabricate the temporary restoration. **Fig 8.** A subepithelial connective tissue graft, harvested from the right, palatal mucosa. A monofilament resorbable suture (Ethicon MONOCRYL) is used to apically position the connective tissue graft between the facial mucosa and the facial bone, as well as the healing abutment. This soft-tissue graft will also serve as a means for bone graft containment. **Fig 9.** The facial mucosa is firmly adapted over the connective tissue graft and healing abutment with resorbable sutures. This reduces the size of the blood clot between the tissue layers, improving healing and providing hemostasis.

from the palatal mucosa in the maxillary right quadrant. The graft was obtained with a single-incision technique, facilitating primary closure of the donor site and without an epithelial collar. Using a thin, periosteal elevator, the marginal portion of the facial soft tissue was gently reflected several millimeters in an envelope manner. The subepithelial connective-tissue graft was placed within this "pouch," lying passively around a narrow, loosely fastened healing abutment (UniAbutment, DENTSPLY Implants). The graft was attached to the facial overlying soft tissue with a monofilament resorbable suture (Ethicon MONOCRYL suture, Ethicon, www.ethicon.com) (Figure 8). The application of the subepithelial connective-tissue graft was to augment the thickness of the peri-implant mucosa, not necessarily to widen the zone of keratinized tissue. Horizontal resorption, which could lead to esthetic compromise, even in thick-biotype patients, has been reported without soft-tissue augmentation.

Using the same suture material, the facial soft tissue was sutured over the connective-tissue graft, compressing the facial and soft tissues and covering a majority of the free soft-tissue graft (Figure 9). The first suture was used to secure the connective-tissue graft between the overlying soft tissue and crestal bone, and the second suture was used to compress the graft and reduce clot dimensions, as well as to achieve hemostasis.

After taking a "baseline" periapical radiograph (Figure 10), the patient was prepared to report to his restorative dentist, taking the poured cast containing the implant replica, which would facilitate provisionalization in vitro, rather than intraorally.

Postoperative instructions included ice pack application for the first 24 hours, systemic antibiotics (amoxicillin, 500 mg, 3 times a day for 10 days), systemic corticosteroids (methylprednisolone for 6 days), nonsteroidal anti-inflammatories for 3 days (etodolac, 400 mg), and 0.12% chlorhexidine rinses twice daily in place of manual toothbrushing for the first 10 days after surgery.

Prior to the initiation of surgical therapy, a vacuum-formed template had been fabricated on a maxillary cast used to facilitate

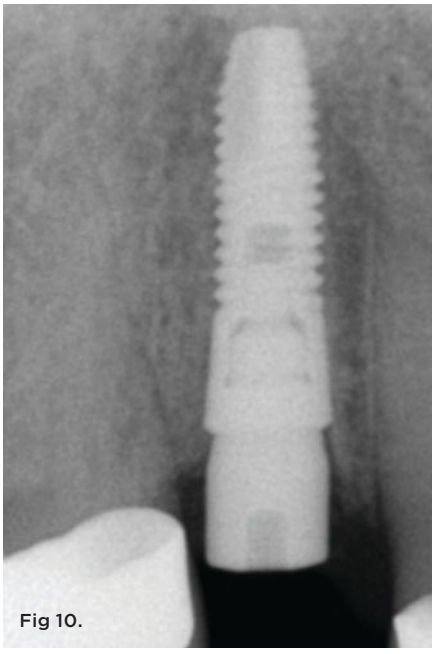
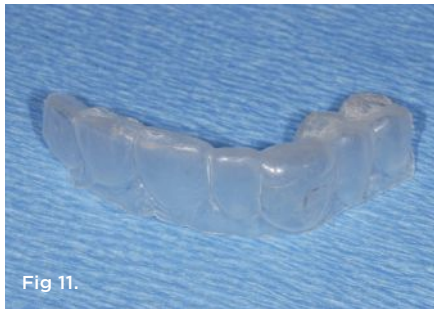


Fig 10.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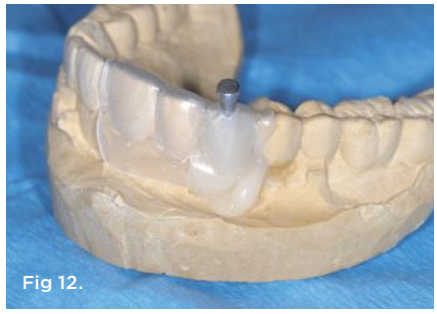
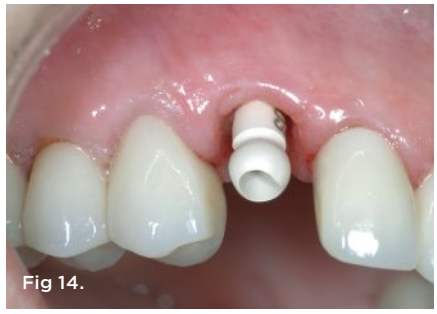


Fig 12.


Fig 13.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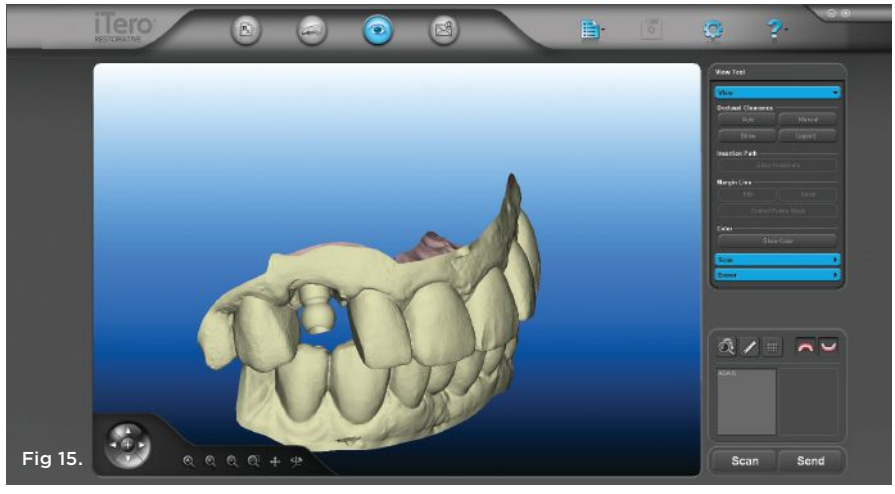

Fig 15.

Fig 10. Radiograph taken immediately after surgery. Implant position is evaluated in relation to the adjacent teeth and proximal bone levels. **Fig 11.** Vacuum-formed template fabricated on the working cast of the patient prior to the fracture of the crown on tooth No. 6. This will be used with the model obtained from the surgical impression to form a screw-retained temporary crown on the bench top, rather than intraorally. **Fig 12.** Bisacryl provisional material (Luxatemp® Ultra) is flowed into the perforated vacuum-formed template after fixation of a temporary abutment to the implant replica. **Fig 13.** The first postoperative appointment, approximately 10 days after surgery. Loose sutures are removed and the area gently debrided/polished. Minimal inflammation is present and a wide band of keratinized mucosa exists. **Fig 14 and Fig 15.** The scanbody (ATLANTIS™ IO FLO) in place to facilitate a digital impression.

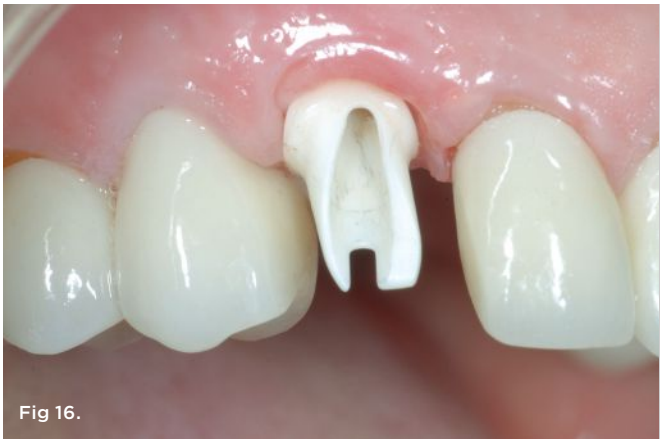
Fig 16.

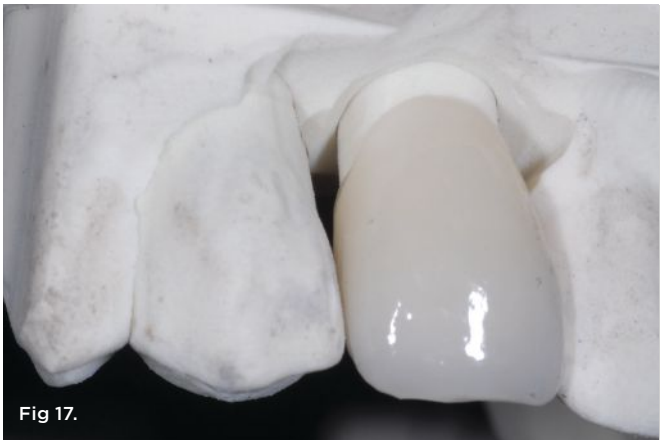
Fig 17.

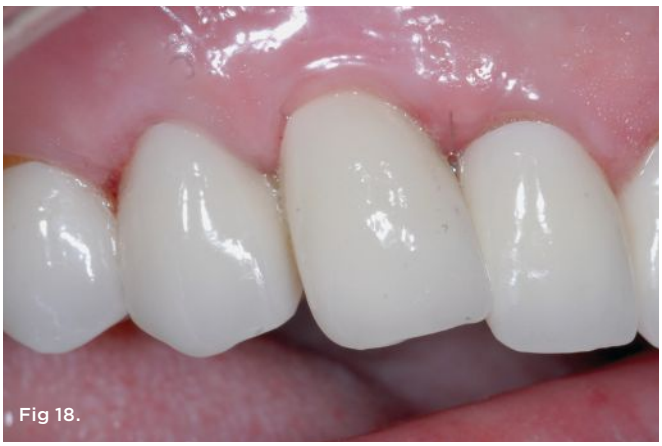
Fig 18.

Fig 16. A zirconia CAD/CAM custom abutment with an abutment screw tightened to 25 Ncm. Note the healthy peri-implant soft tissues and lack of appreciable soft-tissue recession. **Fig 17.** The final crown, porcelain pressed to an all-zirconia core, seated on the final abutment. **Fig 18.** The final all-ceramic crown cemented onto a zirconia CAD/CAM custom abutment.

previous restorative therapy (Figure 11). This template was then used to form a screw-retained provisional crown on the model containing the implant replica from the surgical impression. Bisacryl provisional material (Luxatemp® Ultra, DMG, www.dmg-dental.com) was flowed into the perforated vacuum-formed template after fixation of a temporary abutment to the implant replica (Figure 12).

Contact areas and the emergence profile of the temporary crown were developed on the cast, eliminating the need for repeated placement and removal intraorally, enhancing patient comfort. Great care was taken to confirm no occlusal contacts existed in maximum intercuspation and excursive movements.

At the patient's first postoperative visit, 10 days after surgery, the sutures were removed, the area was gently polished with a rubber cup, and the patient was instructed on the "roll" brushing technique with an extra-soft toothbrush (GUM®, Sunstar, www.gumbrand.com). Over-the-counter essential-oil mouthwash (LISTERINE®, Johnson & Johnson, www.listerine.com) was recommended. The patient was also instructed not to perform any mastication for the next 4 weeks, when he would be returning for clinical and radiographic follow-up. Excellent incorporation of the soft-tissue graft and surrounding soft tissues around the provisional crown was noted (Figure 13).

After 4 months of hard- and soft-tissue maturation, a digital impression was taken. As an alternative to a conventional, rubber-based technique, a scanbody (ATLANTIS™ IO FLO, DENTSPLY Implants) was attached to the implant after removal of the provisional crown (Figure 14 and Figure 15).

With a digital scanner (iTero®, Align Technology, www.itero.com) capturing the position of the scanbody, a digital file was created, facilitating CAD/CAM fabrication of a custom zirconia abutment (ATLANTIS™, DENTSPLY Implants) (Figure 16).

The final crown, porcelain pressed to an all-zirconia core (zerion®, Straumann, www.straumann.com), was seated on the final abutment (Figure 17). Then the final crown was cemented onto the custom abutment (Figure 18).

Conclusion

The present case report demonstrates the efficacy of immediate implant placement, hard- and soft-tissue augmentation, and provisionalization. It is noteworthy that the patient had a thick periodontal biotype, a favorable occlusion scheme, and an intact extraction socket at the time of implant placement. The literature has shown severe esthetic complications even when bone augmentation is performed in these types of situations.[10] The same group demonstrated stability of facial gingival levels in these types of cases when a subepithelial connective-tissue graft was used in conjunction with particulate bone grafts and immediate provisional crowns.[11] Recently, Butler[12] demonstrated the efficacy of autogenous connective-tissue grafts' ability to compensate for the buccal plate diminution following extraction and implant placement.

Another aspect that is featured in this case report is prosthetic design. Abutment contour plays a crucial role, as does the submucosal portion of the crown, in soft-tissue health and esthetics. It is critical that the pressure exerted on the proximal and facial soft tissues is not excessive, leading to apical migration of the marginal mucosa. Recently, Steigmann et al[13] presented an algorithm based on implant position and submucosal contours. Depending on the axial inclination and position of the implant platform in relation to the adjacent teeth, modifications to the submucosal contours

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should be customized. Labial or centered implants require varying degrees of concavity, and over-palatally positioned fixtures require a convex contour to support the soft tissues. These authors also emphasized the importance of provisional crowns to "sculpt" peri-implant soft tissues before delivery of the final restoration.

An additional aspect to this treatment, which is relatively current, is the digital impression technique, rather than traditional, rubber-based impressions. The accuracy of digital scanners when measuring soft-tissue parameters was recently demonstrated by Schneider et al.[14] Ramsey and Ritter[15] demonstrated the digital fabrication of a 3-dimensional model, facilitating fabrication of a virtual abutment with the production of a CAD/CAM-designed custom abutment and all-ceramic crown, delivered to the clinician, seated on a stereolithographic model. Recently, in an in vitro study, Gimenez et al[16] demonstrated the accuracy of a parallel, confocal laser-based impression system, identical to the one used in this case report. They showed the accuracy of recapturing parallel and angled implants with the digital impression technique, noting, however, that accuracy decreased with "shallower" implant placement, as compared to those 2 mm to 4 mm subgingivally. Also, increasing the length of the scan led to slightly less accurate reproduction.

The obvious advantages to the digital impression technique include patient and operator comfort. The unpleasantness of rubber-based impressions is eliminated with this technology. The impression procedure is also of shorter duration, resulting in a more pleasant patient experience.

The distortion of conventional impression materials is not a factor with digital impressions, contributing to their accuracy. Also, distortion related to contraction of gypsum-based stone models is obviated. The virtual reproduction of a working cast, which facilitates virtual abutment design, negates the need to pour traditional models, shortening laboratory working time, and avoids the possible dimensional changes associated with these materials.

As with any procedure, case selection is critical to achieving optimal results. The patient featured in this case report was one with a thick periodontal biotype, lowering the risks of significant postoperative recession.[17] The extraction socket was intact after tooth removal, and his occlusal scheme permitted the placement of a provisional restoration out of contact with the mandibular antagonist teeth. Had any of these criteria not been met, a deviation from the current procedure may have been necessary. This may have included flap reflection and concurrent guided bone regeneration, delayed placement with socket augmentation, or the need for a transitional removable partial denture.

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1. Publication Title: Compendium of Continuing Education in Dentistry®	2. Publication Number: 1 5 4 8 – 8 5 7 8	3. Filing Date: September 14, 2015
4. Issue Frequency: Monthly except combined issues in July/Aug and Nov/Dec	5. Number of Issues Published Annually: 10	6. Annual Subscription Price (if any): Free to qualified subscribers

7. Complete Mailing Address of Known Office of Publication (Not printer): 104 Pheasant Run, Suite 105, Newtown, PA 18940 — Contact Person: Melissa Warner
8. Complete Mailing Address of Headquarters or General Business Office of Publisher (Not printer): 104 Pheasant Run, Suite 105, Newtown, PA 18940 — Telephone: 215-504-1275
9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor (Do not leave blank)
Publisher (Name and complete mailing address): Daniel Perkins 104 Pheasant Run, Suite 105, Newtown, PA 18940
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13. Publication - Compendium of Continuing Education in Dentistry® — 14. Issue Date for Circulation Data: September 2015

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h. Total (Sum of 15f and g)			91,412	91,216
i. Percent Paid and/or Requested Circulation (15c divided by f times 100)			58.7%	58.5%

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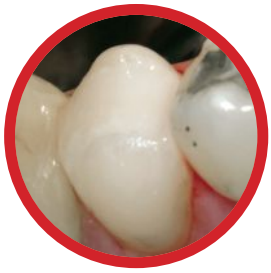

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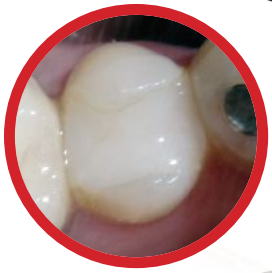

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CARIES DETECTION DEVICES

Use of a Caries Detection Aid in the Conservative Direct Treatment of Caries

Sam J. Halabo, DMD

Abstract: This discussion explores the rationale behind the use of a caries detection aid, the materials currently available, and a case presentation where a caries detection device is used in the treatment of caries in a teenage patient. Although caries detection may not be used in the treatment of every decayed tooth, it can be very effective in making sure all caries are removed, as well as allowing for conservative treatment of teeth.

When it comes to problems in the mouth, clinicians know the importance of catching them early before they get out of hand. Finding problems earlier rather than later not only keeps patients happy and healthy, it saves everyone time and money. The use of digital caries detection technology in today's dental practice is very important for maintaining patient-centered care. Using a caries detection aid allows dentists to practice minimally invasive dentistry. Before a decision is made to cut into a tooth, risk assessment–based early diagnosis and treatment of underlying disease can be applied. In the United States, dental caries in children and adults has been declining for the past 40 years. At this time, however, oral disease continues to be prevalent and presents a major public health issue. As with any disease, early detection is the key to reversing this trend.

Why Use Caries Detection Aids?

There are a variety of opinions and approaches when it comes to using or not using caries detection aids. Clinicians or groups will typically decide in which direction to take their offices. Some clinicians are fully entrenched in the digital world and feel that these devices are the standard of care. Others may deem these devices useful in conjunction with other products in their offices, and a third group may see these devices as unnecessary and costly. While our goal as clinicians is to restore and heal the dentition, we must also do our best to prevent caries growth or arrest it at its onset.

The advent of minimally invasive dentistry has made caries detection aids extremely valuable in the armamentarium of today's clinician. Dentists or, depending on state laws, dental auxiliaries can use these devices, along with magnification and radiographs, for true caries detection[1] during the initial examination or on a recall basis. They can also be used during a procedure to ensure that all decay is removed and to keep a restoration as conservative as possible. Caries detection aids can also be used to help with third-party payment, as the photographs can be far more revealing than dental radiographs alone. Furthermore, these devices can be used to track problems over time, such as wear or cracks. Lastly, and perhaps most important, is that these devices allow patients to see and understand the problem, allowing them to take ownership and understand the need for treatment or preventative measures.

These devices allow patients to see and understand the problem, allowing them to take ownership and understand the need for treatment or preventative measures.

There are a number of caries-detecting devices on the market. The following is a list of the Food and Drug Administration classifications of the different devices[2]:

- DEXIS CariVu™ (DEXIS, www.dexis.com), DIAGNOdent (KaVo Dental, www.kavousa.com), and Microlux™ Transilluminator (Ad Dent Inc., www.addent.com) are in the Caries Detector, Laser Light, and Transmission category.
- DOE SE (DentLight, www.dentlight.com) is in the Ultraviolet Detector category.
- SoproLIFE® (ACTEON North America, www.acteonusa.com), The Canary System® (Quantum Dental Technologies, www.thecanarysystem.com), and CamX Spectra (Air Techniques, Inc., www.airtechniques.com) are in the Laser Fluorescence Caries Detection category.

The Air Techniques CamX Spectra (Spectra), used in the case presented, is an ergonomic digital imaging instrument designed

for the detection of caries while being completely noninvasive. The hand-held device is the size and shape of an intraoral camera and detects tooth decay by measuring increased light-induced fluorescence. Spectra is designed to identify cariogenic bacteria in fissures on occlusal surfaces and can also be used during the restorative phase to verify that all caries have been removed. Light-emitting diodes project high-energy, violet-blue light at a wavelength of 405 nm onto the tooth surface. Light of this particular wavelength stimulates porphyrins (special metabolites of cariogenic bacteria) to fluoresce red, while healthy enamel fluoresces green. Spectra further highlights potential carious lesions in different colors.[3] Along with the colors, a numerical reading defines the potential caries activity on a scale from 0 to 5. The data captured by Spectra are automatically processed and can be viewed and stored within the patient's electronic chart by most compliant dental imaging software programs. Unlike most other caries detection aids, this unit provides an effective visual, as well as a numerical, reading.[4]

There are many advantages to using the Spectra caries detection device. The Doppler radar image created is ideal for patient education. The entire tooth surface is mapped with color-coded areas that indicate not only the presence of decay, but also the estimated depth of the lesion. This allows the patient to truly understand what is occurring in his or her mouth. The caries "map" can discern those lesions that require surgical intervention (drilling) from those that do not.[5] Spectra is an ideal complement to radiographs during patient examinations, as well as an effective tool to promote better oral hygiene. Hygienists can show their patients areas of plaque and tartar they are missing during home care to help prevent decay and periodontal problems. This device can be used as quickly as an inspection with a mirror.

Case Presentation

The patient, a 13-year-old girl, had presented for a recall hygiene appointment (Figure 1 through Figure 3). During her examination, the Spectra caries detection device was used to scan the patient's mouth and to store the photographs of the areas that needed attention. A number of areas revealed the need for treatment. A discussion took place with the patient and her mother regarding treatment plan options for the teeth noted. The lower right quadrant would be treated—particularly tooth No. 28—using Spectra caries detection throughout the procedure (Figure 4).[6]

The patient was anesthetized with with Septocaine® (Septodont, www.septodontusa.com), and a DryShield™ (Incept, www.dryshield.com) isolation unit was used for retraction of the tongue and cheek, as well as high-speed evacuation. During initial visual inspection, the tooth appeared stained, and a sharp explorer detected no soft areas in the enamel (Figure 5).[7] Photographs were taken using the CamX Spectra and the EyeSpecial C-II camera (Shofu, www.shofu.com). Spectra showed two separate readings, 1.6 and 1.2 in the mesial and distal pits, respectively (Figure 6). A Midwest E Electric Handpiece (DENTSPLY, www.dentsply.com) and diamond bur were used to remove the decay.[8] Once the preparation had begun, it was obvious that the decay was present and had penetrated into the dentin (Figure 7), as shown by the higher number—1.9—obtained by the Spectra photograph (Figure 8).[9] To keep the preparation conservative, the Spectra caries detection device was used until no further decay was noted in the tooth (Figure 9).

The preparation was cleaned and dried, leaving a slightly moist surface. The tooth was etched with a 35% phosphoric-acid solution (Ultra-Etch®, Ultradent, www.ultradent.com). A universal


Fig 1.

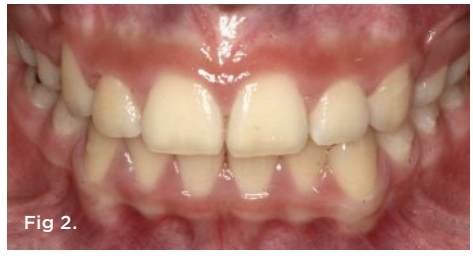
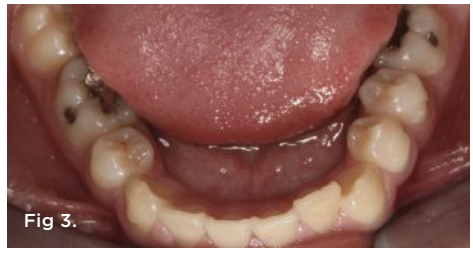


Fig 2.

Fig 1. Patient presenting for treatment on tooth No. 28. **Fig 2.** Facial retracted smile view of the patient. **Fig 3.** Mandibular retracted arch view of the patient. **Fig 4.** Preoperative view of tooth No. 28.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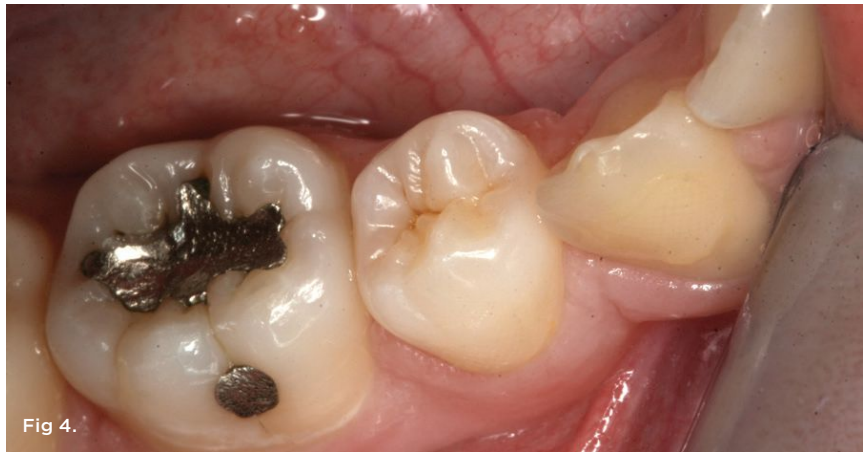
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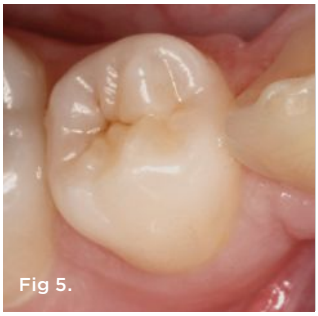
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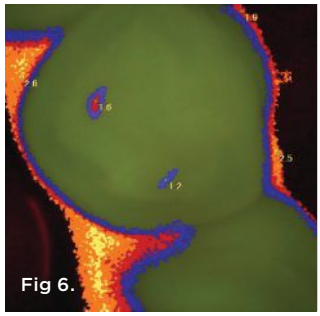
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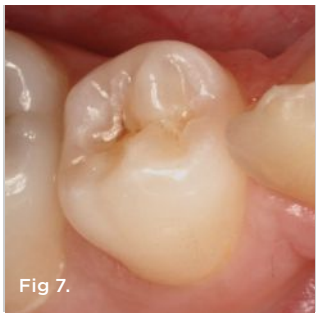
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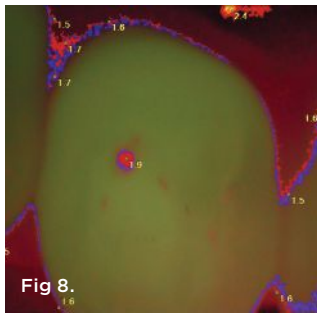
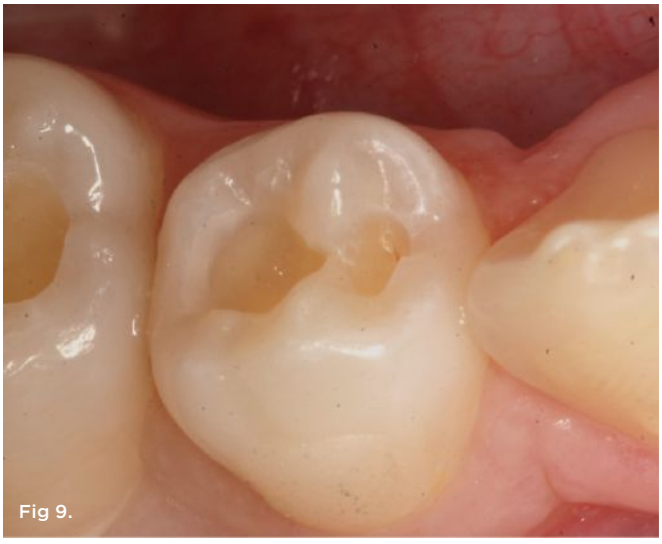


Fig 8.

Fig 5. Close-up view of tooth No. 28 showing stain in the grooves. **Fig 6.** Scan view showing the readings obtained from the Spectra caries detection aid. **Fig 7.** The initial penetration into dentin and depth of the decay. **Fig 8.** Scan following the initial penetration into dentin; the device reading shows further decay requiring additional removal. **Fig 9.** Caries-free tooth ready for restoration. **Fig 10.** The final scan of the tooth after the restoration was placed. **Fig 11.** The final composite restoration.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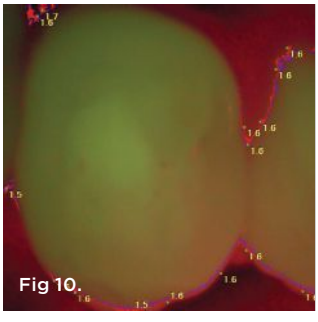
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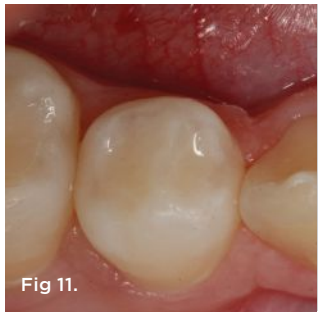
Fig 11.

adhesive (ALL-BOND UNIVERSAL®, Bisco, Inc., www.bisco.com) was scrubbed into the preparation, and the excess was removed with a microtip. The tooth was light-cured for 10 seconds. An A2 shade composite (Herculite™ Ultra, Kerr Dental, www.kerrdental.com) was used. The restoration was contoured, light-cured, and polished.

The final result was esthetic and extremely conservative (Figure 10 and Figure 11). The patient was seen 4 weeks later and reported no sensitivity as a result of the treatment. The techniques and materials used in this case allowed for a conservative treatment while delivering an excellent result for this young patient.

Discussion and Conclusion

This case presented a challenging predicament that clinicians face daily in dentistry. Teeth that may appear caries-free with the use of an explorer can now be examined in more detail with the use of caries detection devices. The availability of reliable devices that allow clinicians to be conservative and assured of the appropriate treatment needed can only enhance dentistry as a profession.

This case showed a successful outcome using modern technology at its best to enhance the result for the patient. Overall, incorporating a caries detection aid into patient examinations (and during treatment) allows clinicians to bring a greater sense of certainty to their diagnosis by providing data to support treatment decisions. Enhanced caries detection capability, clear-cut patient communication, and conservative treatment make these devices indispensable in the dental practice.

ABOUT THE AUTHOR

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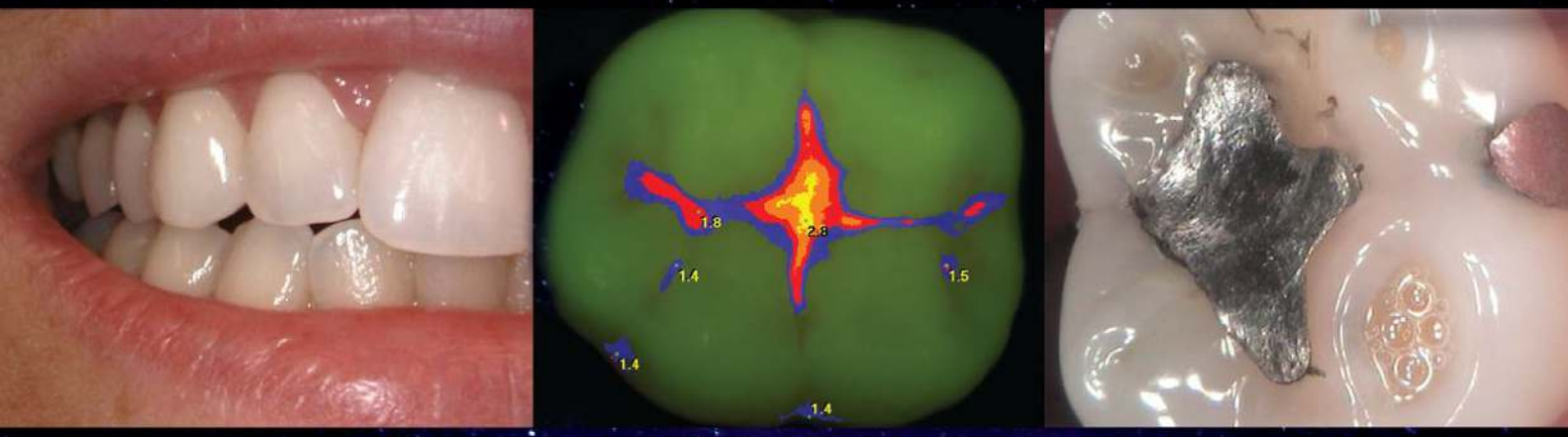

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Microscopic endodontics in infected root canal with calcified structure: a case report

Suehara M, Sano Y, Sako R, et al. *Bull Tokyo Dent Coll.* 2015;56(3):169-75.

ABSTRACT: Calcium deposited within a root canal due to exogenous stimuli may hamper root canal treatment. In endodontic treatment, an operating microscope allows the conditions within the root canal to be directly viewed and evaluated. This report describes a case in which an operating microscope was used to facilitate the excision of a calcified structure from within a root canal at an early stage in the treatment of an infection. An 18-year-old man was referred to our clinic due to suspected chronic suppurative apical periodontitis of the right maxillary central incisor. Periapical radiography confirmed the presence of a radiopaque structure inside the root canal that was likely to pose an obstacle to endodontic treatment. After opening the pulp chamber, an operating microscope was used to directly confirm the presence of the calcified structure in the root canal, which was removed using an ultrasonic tip. The infected root canal was treated using calcium hydroxide. Two months later, closure of the apical foramen as a result of calcification of the apical foramen was confirmed and the root canal filled. Using an operating microscope to directly view a structure posing an obstacle to root canal treatment made it possible to perform an excision while avoiding risks such as canal perforation.

Oral infections, metabolic inflammation, genetics, and cardiometabolic diseases

Janket SJ, Javaheri H, Ackerson LK, et al. *J Dent Res.* 2015;94 (9 Suppl):119S-27S.

ABSTRACT: Although several epidemiologic studies reported plausible and potentially causal associations between oral infections and cardiometabolic diseases (CMDs), controversy still lingers. This might be due to unrecognized confounding from metabolic inflammation and genetics, both of which alter the immune responses of the host. Low-grade inflammation termed metainflammation is the hallmark of obesity, insulin resistance, type 2 diabetes, and CMDs. According to the common soil theory, the continuum of obesity to CMDs is the same pathology at different time points, and early metainflammations, such as hyperglycemia and obesity, display many adverse cardiometabolic characteristics. Consequently, adipose tissue is now considered a dynamic endocrine organ that expresses many proinflammatory cytokines such as TNF-α, IL-6, plasminogen activator inhibitor 1, and IL-1β. In metainflammation, IL-1β and reactive oxygen species are generated, and IL-1β is a pivotal molecule in the pathogenesis of CMDs. Note that the same cytokines expressed in metainflammation are also reported in oral infections. Additionally, genetics influence CMDs, and this creates a confounding relationship among oral infections, metainflammation, and genetics. Therefore, future studies must elucidate whether oral infections can increase the risk of CMDs independent of the aforementioned confounding factors.

Pathological evaluation for sterilization of routinely used prosthodontic and endodontic instruments

Kumar KV, Kiran Kumar KS, Supreetha S, et al. *J Int Soc Prev Community Dent.* 2015;5(3):232-6.

ABSTRACT: In the daily practice of dentistry, we use the same instruments on many patients. Before use, all instruments must be cleaned, disinfected, and sterilized to prevent any contamination. Pre-cleaning and sterilization of some devices can be difficult because of their small size and complex architecture. Dental burs and endodontic files are such instruments. Dental burs come in a variety of shapes and sizes, all with highly complex and detailed surface features. The aim of the study was to determine the effectiveness of various disinfectants and sterilization techniques for disinfection and resterilization of dental burs and endodontic files. Disinfectants used were Quitanet Plus, glutaraldehyde, glass-bead sterilizer, and autoclave. The sterility of used dental burs and endodontic files was analyzed. Burs and files that had been used were precleaned, resterilized, and then tested for various pathogens. Each item was transferred by sterile technique into Todd Hewitt Broth, incubated at 37°C for 72 h, and observed for bacterial growth. The present study shows that the endodontic files and burs sterilized by autoclaving and glutaraldehyde showed complete sterilization. Burs and files immersed in glutaraldehyde (2.4%) for 12 h showed complete sterilization, whereas Quitanet plus solution and glass-bead sterilizer showed incomplete sterilization.

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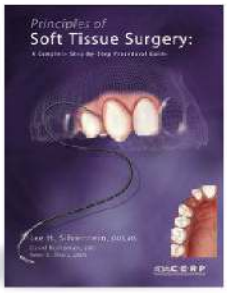

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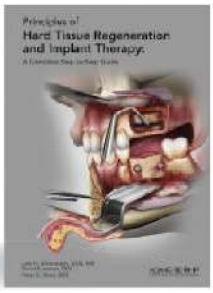

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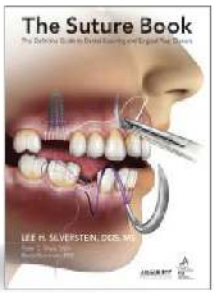

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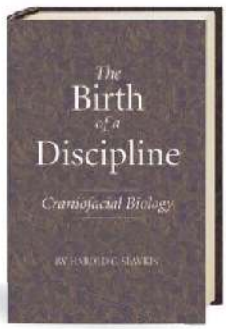

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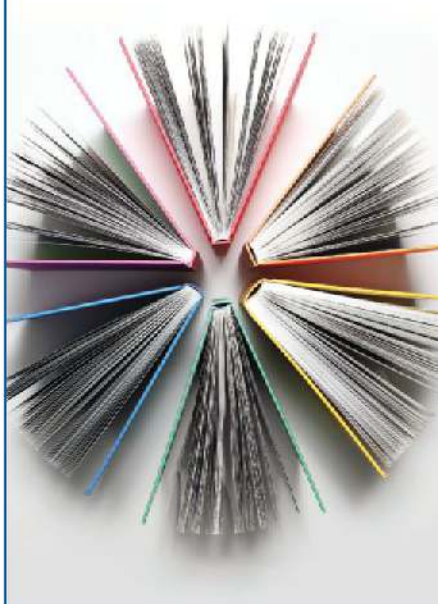

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PREVENTION/ORAL HYGIENE

Oral Hygiene: Here We Go

Michael Rethman, DDS, MS

Excellent oral hygiene can prevent or limit the harms associated with the most common oral diseases, namely caries and the periodontal diseases. Furthermore, optimal oral hygiene is often critical to the success of clinical procedures aimed at halting or reversing the damages caused by oral diseases.

Oral hygiene includes professional (eg, prophylaxes, fluoride treatments, etc.) and self-care endeavors. The term *self-care* consists of oral hygiene endeavors performed by individuals on themselves or as caregivers for others, eg, invalids. All serve patient-centered goals, namely oral comfort, adequate function, and esthetics—including pleasant breath odor.

Oral Hygiene: Past and Present

Early in human history, oral self-care targeted impacted food and problematic teeth. Although the ancients knew nothing about the biology of oral diseases, rudimentary self-care tools included chewing sticks, twigs, feathers, and animal bones. Over the past century, efforts to optimize oral hygiene as a means to enhance prevention or to limit disease progression have increased.[1]

In the 1930s "See your dentist twice a year" and "Brush your teeth twice a day" became popular aphorisms. Nearly a century later, no quality evidence exists to support such claims. However, it now seems clear that some people need frequent professional care and intensive self-care, while others need less.[2]

Increased societal interest in dental health was an indirect effect of World War II, when many military draftees were rejected because of extremely poor oral health. This led to the creation of the National Institute of Dental Research in 1948. Research later confirmed that the "dental film" (aka, dental plaque and more recently termed *dental biofilm*) played an important role in the etiologies of dental caries and periodontal diseases. Once dental plaque was identified as causal for caries and the periodontal diseases, the biological rationale for optimal oral hygiene became clear.[3]

Pre- and post-WWII advertising by dentifrice companies encouraged patients to improve self-care, and also encouraged professionals to increase professional oral hygiene services. Eventually, it became clear that the amount of dental plaque did not always correlate with the likelihood or severity of dental diseases. Rather, it became evident that the bacterial makeup and the anatomic location of the plaque were more critical determinants of oral health or disease.[4] It also became clear that undisturbed dental plaque changes in character over time, typically becoming more harmful.[5]

> Individualized diagnostics, including genetic tests, will better identify those who need more intensive oral hygiene interventions. Ideally, such information would be available and acted on early enough in life to prevent or limit caries and the periodontal diseases.

Dental calculus (ie, tartar) has long been linked to poor esthetics and the periodontal diseases. Calculus removal was often a key focus of early dental hygienists and dentists. Later came evidence that calculus per se was not causal, but rather the bacteria that populated it could cause periodontitis. This led to confusion regarding the importance of preventing or removing calculus. It now appears that the frequent removal of all macroscopically visible calculus, whether supragingival or subgingival, is part of any regimen aimed at ensuring optimal oral health.[6]

By the 1930s, epidemiological studies reported lower caries rates in some localities. Higher concentrations of fluoride ions dissolved in municipal water supplies were implicated. Although technically not self-care, beginning in 1945, low concentrations of fluoride were added to more municipal water supplies. Unfortunately, the enamel component of teeth tends to become undesirably mottled if dietary fluoride is too high.[7] Some experienced mottling, even in cities where fluoride concentration was held to only 1 part per million. Therefore, the recommended concentration of fluoride in water supplies is now 0.7 parts per million.[8]

Dentifrices (toothpastes) began replacing dental powders in the 1920s and 1930s. Diluted sodium lauryl sulfate detergent became a popular component of dentifrices because a sudsy mix contributed to patients' post-brushing perceptions of cleanliness.

Michael Rethman, DDS, MS
Adjunct Associate Professor, Baltimore College of Dental Surgery, University of Maryland; Adjunct Assistant Professor, College of Dentistry, The Ohio State University

In recent years, the addition of specific ingredients to dentifrices and rinses has been found to better mitigate existing caries and gum diseases, especially when those maladies are addressed in their nascent stages. In the 1960s, fluoride was added to dentifrices (later to mouthrinses) to inhibit caries. Agents (eg, pyrophosphate) were added to inhibit the formation of dental calculus. The antiseptic triclosan was compounded in some dentifrices; it promptly kills bacteria and is substantive, meaning it remains active for hours after its application. All of these additives have been shown to be at least somewhat beneficial. Some dentifrices include more than one active ingredient and show efficacy against both caries and gingivitis.

Bioactive agents have also been introduced into appliqués and mouthrinses. Among these ingredients are fluorides, essential oils, quaternary ammonium compounds (eg, cetylpyridinium chloride), and chlorhexidine. Many offer better means to assist certain patients, especially caries-prone children and the elderly.[9,10]

Rinses are popular; a rinse containing "essential oils" has been advertised as a germicide for a century. It is somewhat effective against the mildest of the periodontal diseases, namely gingivitis. Chlorhexidine rinses are substantive and highly potent antimicrobials, but stain teeth and may affect taste sensation. Such shortcomings make chlorhexidine rinses appropriate for brief intervals, eg, after certain types of periodontal therapy.

Powered toothbrushes were first introduced in the 1960s. When properly used, ample evidence exists to support their superiority. However, manual toothbrushes can achieve similar results but with more effort.

Tongue cleaning has gained popularity in recent years based on the observation that the tongue's rough dorsum harbors bacteria that can facilitate the microbial re-population of newly cleaned teeth. Data also suggest effectiveness against halitosis.[11]

Oral Hygiene: The Future

Some of what follows may seem fanciful. The key to widespread implementation is whether each makes sense from a cost (risk)-versus-benefit standpoint.

Individualized diagnostics, including genetic tests, will better identify those who need more intensive oral hygiene interventions. Ideally, such information would be available and acted on early enough in life to prevent or limit caries and the periodontal diseases. Delta Dental of Michigan recently introduced a program in which patients at lower risk of oral disease are benefited for fewer periodic prophylaxes and examinations. Those who test at higher risk are benefited for additional professional interventions. Although notionally sound, this effort is based on averages and confounded by an administrative bias against tobacco users. Thus, the risk is that some who are examined less often may incur otherwise-avoided oral health problems.

As the average age of Americans increases, oral hygiene emphasis will be multi-modally enhanced for invalids and those for whom better oral health may translate into decreased risk or morbidities for systemic diseases. Also, technologies that make interdental cleaning easier will become mainstream.

There will be improved understanding (both professional and patient) of preventive care aimed at the completely or partially edentulous, with or without osseointegrated implants. Those with complete dentures infrequently visit dental professionals, thereby putting themselves at a greater risk for less common oral diseases, such as advanced squamous cell carcinoma. Similarly, it is unclear whether or how oral health may be linked to the growing incidence of oropharyngeal cancer caused by sexually transmitted human papilloma virus.

After 35 years of osseointegrated dental implants, dentistry is now more widely addressing implant maintenance issues. It should come as no surprise that the same patient-specific causes of natural tooth loss may also put implants at risk. Indeed, it has become increasingly clear that oral hygiene tactics designed for implants are critical to their maintenance.

The causal links between oral health and systemic health will become better-known by the public, thereby driving increased attention to optimal oral hygiene.

Improved availability of Internet-based services will improve the average information technology capabilities of tomorrow's patients. Tactics to guide users to reputable sources of information will become better and more successful.

Optimal self-care regimens will be refined. For example, it may make no difference to the oral health of some patients if they perform self-care once, twice, or more times each day. It may also matter little if brushing times (2 minutes is today's general recommendation) are cut or increased in duration. Also, efforts to make self-care easier will gain in popularity.

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Cavitron Touch™: Unprecedented Control and Comfort for Patient and Hygienist

Gail Malone, RDH, BS, who is the Senior Manager of the Clinical Education team for DENTSPLY Professional, says that since DENTSPLY introduced the first Cavitron® unit in 1957, ultrasonic scaling has emerged as an important hygiene tool. "In general, ultrasonic scalers provide an efficient and effective way to remove calculus and plaque biofilms during routine prophylaxis procedures and periodontal therapy to maintain healthy tissues or to treat gingivitis and other periodontal diseases. Combined with an effective patient self-care, these measures support improved patient oral health," she says.

Malone notes the many innovations that have occurred in both the technology and the insert tip design since the introduction of that first model more than 50 years ago, and observes that the latest Cavitron Ultrasonic inserts and scaling systems work together for an optimized performance. For example, she describes special features that contribute to patient safety and comfort, as well as in an improved ability of the hygienist to use the technology to maximum advantage. "Cavitron Ultrasonic Scaling Systems provide the added features of an extended low-power Blue Zone, which is designed for improved patient comfort, and a detachable and autoclavable handpiece to reduce cross-contamination for enhanced infection prevention," she maintains. "The wide array of Cavitron ultrasonic insert designs provides the clinician with multiple options for adaption and access to all areas of the oral cavity," she explains. "The slimLINE series of inserts is designed for removal of light to moderate deposits. With multiple tip designs to choose from, these inserts provide improved subgingival access and allow for adaptation to the root anatomy." The PowerLINE series of inserts is specifically designed for the efficient removal of heavy deposits, she adds.

Malone remarks that Cavitron Ultrasonic systems address issues related to the comfort and health of dental health professionals. "Musculoskelatal disorders have long been cited as reasons for early retirement among dental health professionals. Ergonomic considerations may contribute to a more comfortable work experience for the dental hygiene clinician," she asserts. "The newly introduced Cavitron Touch Ultrasonic Scaling System offers unprecedented comfort and control throughout every procedure. It offers an ergonomic design with lightweight cable and a fully rotating Steri-Mate® 360 handpiece that allows free-flowing movement and access within the oral cavity, as well as an innovative touch-screen interface."

Malone considers focusing on risk assessment and the disruption/management of dental biofilms as positive steps toward prevention. Mature plaque biofilms, she explains, release a variety of biologically active products including endotoxins, cytokines, and other toxins that initiate the inflammatory response, which can lead to the destruction of the periodontal tissue. "Prophylaxis and periodontal treatment support not only oral health but also overall health by reducing inflammation, which is now known to play a role in chronic diseases," she says. Stressing that patients at high risk for elevated systemic inflammation require more frequent and aggressive treatment, she says, "Individuals respond differently to periodontal inflammation, systemic inflammatory burden, and anti-inflammatory therapies because of genetics, enviornment, and lifestyle choices."

Hopeful for dental disease prevention in the future, Malone's "laundry list" includes "new methods of disease detection in the subclinical phase prior to the appearance of clinical signs; innovation in diagnostic tools; greater emphasis on risk assessment and the correlation of dental health to overall health; and vaccines for prevention of dental caries."

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CAV27-0715-2

Resin Infiltration of Incipient Caries with Icon: A Patient-Friendly Approach to Caries Control

Jonesboro, AR, private practitioner W. Johnston Rowe, Jr., DDS, AAACD, is encouraged by a new understanding of dental disease that is changing treatment."For years we thought we were treating the disease causing tooth decay as we restored damaged tooth structure. We understand now that we were not treating the disease's cause—ie, bacteria—but were merely managing its symptoms," he asserts.

"Ongoing research in the area of cariology has allowed us to better understand the caries process, which involves bacteria attaching themselves to tooth structure, establishing colonies, and forming protective biofilm through the utilization of simple sugars," he continues. "It is clear that the caries process is driven by the presence of simple sugars within the diet; we also know that the pH level of the mouth, at any given time, is directly affected by the presence of cariogenic bacteria."

To address the organisms causing carious lesions, Rowe says, new remineralization products and restorative procedures are designed; this results in the preservation of tooth structure, which in the past was sacrificed for the purpose of mechanical debridement and restoration. "Through the understanding of bacteria, researchers have been able to develop new and more effective remineralization strategies utilizing fluoride, ACP, CPP-ACP, and bioactive glass materials. These materials, not available a decade ago, have proved to be useful tools in addressing the slowing of the caries process and the rebuilding of tooth structure," he maintains.

DMG America has introduced a resin infiltrant, an effective new concept in the restoration of demineralized tooth structure. "The introduction of the resin infiltration technique utilizing DMG America's Icon® system," Rowe says, "has provided dentists with a new tool that is effective in preserving tooth structure while disrupting the caries process." Designed to treat incipient caries, rather than waiting for the need to initiate more invasive approaches—ie, drilling and filling—he says that Icon fills, reinforces, and stabilizes demineralized enamel without drilling or sacrificing healthy tooth structure.

In this way, Rowe explains, resin infiltration of the carious lesion bridges the gap between chemical remineralization efforts and aggressive mechanical restoration. Citing additional benefits, he says, "Resin infiltration eliminates the need to anesthetize a patient to restore a lesion, and it only requires one office visit, thus eliminating the frustrations of return visits and need for patient compliance. Because the active cavity is treated completely in one visit, it increases the percentage of success in restoration and sets the stage for subsequent potential remineralization." Rowe observes that approaches such as resin infiltration with Icon to slow or reverse the caries process are especially important because their success does not depend on stringent patient compliance and/or numerous repetitive applications of medicaments over time. "Despite the best efforts of dental professionals and patients, too often, the caries process continues, resulting in the need to employ aggressive mechanical restoration. In many cases, utilization of Class II restorations leads to the removal of a significant amount of healthy tooth structure relative to a significantly smaller amount of decayed tooth structure purely to access the carious lesion."

Rowe, who uses Icon in his own practice, says DMG America provides in-office continuing education for clinicians who are interested in learning more about resin infiltration as a viable means of treating incipient caries lesions. "It provides clear guidelines for determining proper treatment selection, including criteria based on lesion type, lesion depth, and surface quality. The capabilities and limitations of treating incipiencies through the caries infiltration process are also addressed," he says.

Rowe is optimistic that caries control will continue to improve using integrated approaches. "Appropriate protocols of periodontal therapy, hygiene instruction, chemical remineralization, resin infiltration, and conventional mechanical restoration of carious lesions, each where appropriate, all work together in clinical practice to provide effective treatment of caries as a disease."

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Single Use Sterilization Pouches: Little Things Matter

Noel Kelsch, RDH, RDHAP, AS, BS, is an international speaker, writer, and researcher. As a registered dental hygienist, she maintains a private dental hygiene practice, and devotes much of her work life to the underserved in public health and hospice environments.

Kelsch is the infection control columnist for a national magazine, and feels strongly about the need to properly manage infection control in the dental office. "We never want to bring a patient into an office, then be the ones that make them sick," she says, especially while performing procedures meant to treat and prevent oral disease.

Kelsch stresses that, when it comes to infection control, "sometimes it's the small steps that makes the big difference." Infection control, she says, is a series of steps needed to ensure the safety of staff and patients. She describes the basic steps for sterilization as: (1) transport; (2) clean, utilizing an automated system as much as possible; (3) rinse and dry; (4) package; (5) sterilize for a complete cycle; and (6) store.

A sterilization pouch is a medical device approved by the Food and Drug Administration.[1] Its profile includes that it must allow penetration of the sterilant, and provide protection against contamination during handling and storage.[2] A properly used sterilization pouch will, therefore, provide an effective barrier against contamination until reuse.

Kelsch maintains that among the pouches on the market, the PeelVue Sterilization Pouch from KerrTotalCare takes that technology a step further.

1. It is a self-sealing paper/clear plastic pouch that provides good visibility to the procedural instruments, the code rings on dental instruments, and the internal process indicators.
2. Its Closure Validators are guiding arrows that provide a visual guide to achieve a properly sealed pouch, and are designed to prevent contaminants from re-entering the pouch.
3. A wide adhesive flap easily folds at the perforation to assure a uniform fold-and-seal action.
4. Non-adhesive edges allow for easy peel, with or without gloves.
5. Internal and external indicators assure the sterilization process has occurred.
6. Thirteen sizes accommodate the needs for instruments and/or cassettes and the sterilization equipment.
7. PeelVue Sterilization Pouches are color-coded to easily differentiate sizes and easily facilitate reordering.
8. Lead-free inks allow disposal of PeelVue Sterilization Pouches in unregulated trash.

Kelsch notes that infection control is a core value of Kerr TotalCare. The company's philosophy is to help create a safe, comfortable environment for the clinician and the patient. With this in mind, she offers the following hints for correctly using PeelVue Sterilization Pouches.

Hints

1. Pouches are designed for single use; do not reuse.
2. Allow the pouch to dry before removing from sterilizer to prevent wicking of pathogens.
3. Store pouches in an undisturbed place that is cool and dry.

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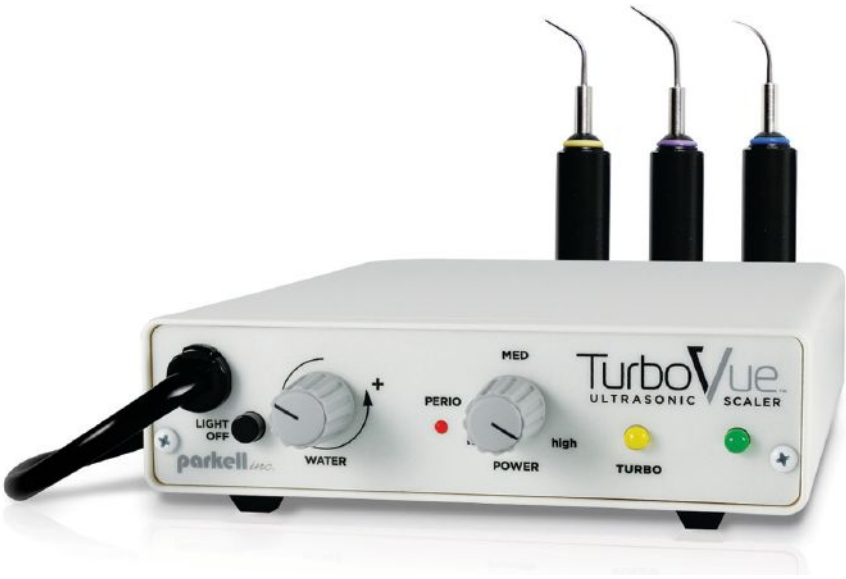
TurboVUE Lighted Handpiece Ultrasonic Scaler Takes Aim at Inflammatory Pathogens

Betsy Reynolds, RDH, MS, who is a dental hygienist and oral biologist in Idaho, presents scientifically based dental and dental hygiene continuing education programs nationally and internationally.

She recalls when Paul M Ridker, MD, connected heightened C-reactive protein and inflammation in 2005 as a landmark, and says, "In my opinion, the biggest trend that has been taking place in the last 10 years has been recognizing that inflammation—no matter where it is in the body—has a negative impact on overall health," she says, adding, "This finding put the whole dental industry—especially dental hygiene—on its ear in terms of what we believed." Since then, she says, "It's been exciting for dental hygienists to see how treating inflammation in the practice setting and integrating anti-inflammatory techniques for homecare helps patients maintain not just better oral health but better overall health," which, she says, has become the focus of her continuing education programs.

Reynolds also says a better understanding of biofilm and plaque is driving different approaches to hygiene, approaches that focus less on eliminating all "bugs"—some of which have a positive impact on the oral environment—than the plaque that is destructive, in order to maintain a healthy environment. "There is now a recognition that some bugs are good and should be left alone or encouraged," she claims.

Reynolds says ultrasonic scaling has become an integral component of routine dental hygiene care, but is unlikely to ever replace hand instrumentation entirely. "While some hand scaling is still used in the vast majority of cases, ultrasonic not only more gently severs the bond between plaque and tooth surface, it also removes hard deposits, staining, and loose debris, while providing lavage and acoustic streaming."



She says the addition of light, such as is now provided with Parkell's TurboVue™ Illuminated Magnetostrictive Ultrasonic Scaler, is a welcome improvement. This uniquely engineered device does in fact provide excellent visibility when scaling all areas of the oral cavity, she says. "The TurboVue features a light source built into the handpiece, allowing a significant amount of light to emit through the 30K light-transmitting ultrasonic inserts," she explains. The TurboVue also features auto-tuning technology, a dramatically expanded low-power range that improves comfort during debridement, and has a power-boosting turbo feature for an increase in scaling power when needed.

Reynolds says she is "a huge fan of the Parkell inserts," which she considers to be sturdy and long lasting as well as well functioning. Among the Parkell inserts is the Burnett, which she states is well known among hygienists and periodontists for its ability to remove tenacious deposits, as well as to effectively run at the lowest to the highest power setting on the scaler.

In addition to the Burnett Power-Tip V, the 30K light-transmitting inserts that emit light from the handpiece include the Universal Tip V and the Straight Perio Tip V; all feature a durable, autoclavable glass sleeve to transmit the light from the handpiece to the operating field. The GentleClean Cushion-Grip insert, which is not part of the TurboVue Light Transmitting Inserts, says Reynolds, is a unique insert specifically designed to be used around implants and ortho brackets. "This insert really allows pain-free scaling. It removes biofilm plaque and soft calculus from metal and teeth, and it won't scratch or damage restoration margins. It is especially useful for treating children and hypersensitive patients. In addition, it has a soft grip that makes it comfortable for the operator to use."

As Reynolds sees it, ultrasonic technology—including toothbrushes—is very much in step with the trend toward understanding that oral and general health are one and the same, and that what benefits one benefits the other. "Once we can control the micronome better and control health, office time can be spent more on inflammation control, not just deposit removal, filling, and drilling," she concludes.

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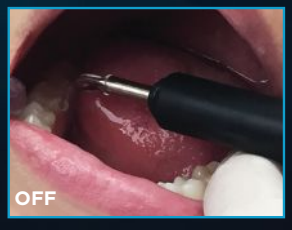

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Easier Flossing with AirFloss Pro from Philips Sonicare Supports Oral and Overall Health

Barbara J. Steinberg, DDS, who is Clinical Professor of Surgery at Drexel University College of Medicine in Philadelphia, PA, observes that patients are more motivated to take better care of their oral health because of recent reports linking oral and general health. "Patients are learning more about how oral health is related to systemic health, and the relationship of periodontal diseases to heart disease, stroke, pneumonia, preterm/low birth weight babies, and certain types of cancer, etc.," she says.

Other than the American Dental Association's recommendation that people chew sugarless gum 20 minutes after meals to help prevent caries, Steinberg says that not much has changed in terms of personal oral healthcare protocol. "People still need to brush for 2 minutes, twice daily, and clean interproximally every day," as well as drink fluoridated water, and avoid between-meal snacks.

Fortunately, she says, there are tools that make it easier to comply with the "Big 2" in home-care—brushing and interproximal cleaning.

Steinberg herself admits to being a relative latecomer to power-toothbrush use. She believed that, as a dentist, she was able to brush optimally with her trusty soft-bristled manual toothbrush and excellent technique. "I was a believer in manual toothbrushing until about 15 years ago, when I personally used a Philips Sonicare and made the decision to switch to a power toothbrush," she recalls. Steinberg uses the Philips Sonicare Flexcare Platinum model and believes everyone—particularly patients—could benefit from the technology. As for her own conversion, she says, "It's not just the science—ie, that the bristles provide 4 times more tooth surface contact and deliver 7 to 10 times greater plaque removal—that keeps me using my Sonicare. My teeth feel cleaner, and, based on my dental checkups, I know I'm now doing a better job of keeping my teeth clean and my gum health in a more optimal state."

Steinberg makes it clear that the Philips Sonicare line of brushes is available at all price points, and the features and benefits increase with model advancement. Among commonly available features are modes for sensitive teeth and a timed quadrant pacer to signal when to move the brush to another section of the mouth.

Given that traditional flossing is the oral healthcare task people generally dislike the most, Steinberg has been recommending the Philips Sonicare AirFloss Pro, which is clinically proven to be as effective as flossing, removing up to 99.9% of plaque that brushing misses. This device, she says, delivers three bursts of air and liquid micro-droplets between the teeth to disrupt and remove plaque interproximally and in hard-to-reach areas during a single 60-second treatment.

Steinberg considers the Philips Sonicare AirFloss Pro a boon to personal healthcare, mainly because it responds to a reality: most people don't or can't floss as often as they should. "I personally don't mind flossing, but for the person who hates to floss and/or performs it inconsistently, this is as efficacious as flossing for removing plaque and food debris," she maintains.

Steinberg says that excellent oral home-care is essential to maintaining good health, but neither professional care nor home-care is a substitute for the other. "However acceptable someone's home-care might be," she says, "patients should be evaluated regularly by their oral healthcare provider." A routinely scheduled professional checkup, she points out, also serves to detect other disease conditions—including oral cancer—that the patient would otherwise be unaware of. Steinberg notes that an annual visit may not be sufficient for all patients, especially those who are prone to periodontal diseases or caries. "Their recare schedule should be determined by keeping with their individually specific oral and overall health status to assess, monitor, and treat them as needed," she says.

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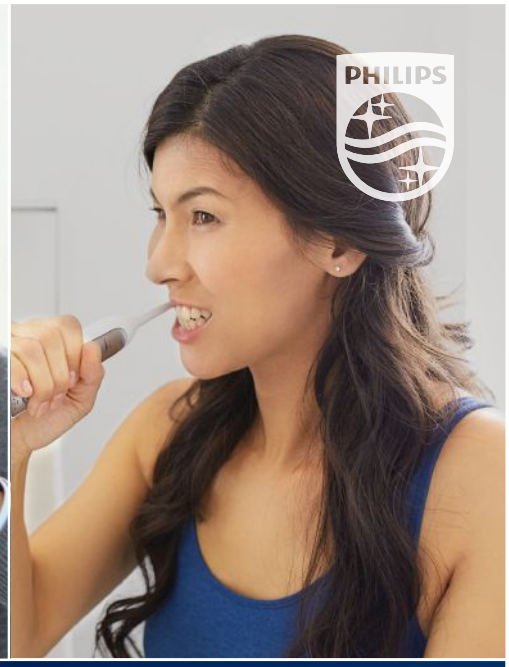

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Chlorhexidine Efficacy Without the Alcohol: Another Novel Introduction from Sunstar

Sunstar's Aaron Pfarrer recently discussed how the company takes both conventional and innovative approaches to support oral health, which was recently recognized as intrinsically interwoven with overall health.

Pfarrer, who is Senior Director of Professional Relations, points to a tradition of launching products that are easy to use as well as efficacious, thereby encouraging patient compliance. This, he says, is the case with its alcohol-free Paroex® Chlorhexidine Gluconate Oral Rinse USP, 0.12%, which is currently the only FDA-approved alcohol-free chlorhexidine rinse. "Because there are certain patient populations for whom the health professional may choose to prescribe an alcohol-free alternative, this product is an effective option that makes it easy for patients to adhere to their doctor's treatment plan," he explains.

Pfarrer notes a trend among consumers, who are increasingly opting for alcohol-free versions of a wide range of products, from hair gel, insect repellent, and skin cleansers to OTC and prescription medications, due to a preference or need to avoid products containing alcohol. The 4 oz. size of Paroex makes it more convenient for practices to send the product home with their patients, which provides Paroex with another way to contribute to higher levels of patient compliance.

Pfarrer also points out that Paroex is specifically approved by the FDA for use between dental visits as part of a professional program for the prevention and treatment of gingivitis, because, as a broad-spectrum antimicrobial agent, it is effective in controlling plaque. However, he adds, in addition to being alcohol-free, Paroex is therapeutically equivalent to other, alcohol-containing chlorhexidine gluconate 0.12% rinse products, which, as broad-spectrum antimicrobials, may sometimes be used by dental professionals as a pre-procedural or post-procedural rinse.

Pfarrer expresses how Sunstar's tradition of bringing innovation to healthcare comes at an especially fortuitous time. "Sunstar is committed to new and novel approaches for the prevention of disease in recognition of the important link between oral health and systemic health. This is why you see not just one, but several products offered by Sunstar in the plaque-controlling area, including probiotics, antimicrobials, and plaque-controlling rinses that don't contain alcohol," he says.

Pfarrer stresses Sunstar's longstanding commitment to creating simple, patient-friendly approaches to improved homecare, including products geared toward those who find it difficult to comply with recommended traditional approaches. For example, GUM® PerioBalance® is a mint-flavored probiotic lozenge developed to reduce harmful dental plaque and promote healthy teeth and gums when taken daily. Both GUM® Soft-Picks® and Proxabrush® Go-Betweens® Cleaners offer an alternative to string-flossing for those who find it difficult or unpleasant. "Products such as these can remove obstacles that inhibit people from caring properly for their oral health. There are also numerous toothbrushes—both power and manual—to meet the needs of patients those with healthy gingiva, restorations, orthodontics, periodontal disease, or post surgery."

Pfarrer says Sunstar is continuing to study, understand, and remain poised to launch innovations geared toward oral and systemic health. "We bring innovation not just in the prevention market, but also in bone grafting and tissue regeneration through our GUIDOR products."

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*Source: SDM, March, 2015 and IRI 52 weeks ending 5/17/2015 1. Yost KG, Mallatt ME, Liebman J: Interproximal gingivitis and plaque reduction by four interdental products. J Clin Dent 2006; 17: 79-83.

SUNSTAR

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Needle-free Anesthetic Offers Pain Control During Periodontal Treatment

With several years as a tenured dental hygiene educator, followed by 11 years as a corporate dental hygienist, Doreen Johnson, RDH, MA Ed, brings a wealth of knowledge to her position as Clinical Educator for DENTSPLY Professional, covering the Midwest Region of the United States.

Describing current trends in dental disease prevention from the perspective of the dental hygienist she is by training, Johnson says much has changed in recent years. "It was a good day for dentistry when the head and neck were recognized as being connected to rest of the body, compared to years ago when they were evaluated in a very different light," she observes. She says part of connecting the mouth to the rest of the body means understanding the perio-systemic link—that inflammatory conditions such as cardiovascular disease and diabetes, as well as unhealthy behaviors such as poor nutrition and smoking, contribute to dental disease. "Dental hygienists, as well as other dental team members, must be aware of factors now known to contribute to dental disease and be able to identify them when looking for causes of periodontal disease and dental caries in specific patients," she maintains. Johnson says that seeing the body as a complete system facilitates a comprehensive approach to prevention, allowing the clinician to identify contributing factors and early disease indicators, and provide the patient with solid treatment options." Therefore, she says, there are more assessments for those factors, as well as those that are more traditionally dental, such as for caries, periodontal disease, and hypersensitivity, etc. They include methodical forms such as Caries Management by Risk Assessment (CAMBRA), which aims to identify the cause of disease by eliciting, evaluating, and managing individual patient risk factors through behavioral counseling and treatments.

Noting the role of new technology, agents, and treatments, she says, "Advances in technology that have impacted this aspect of dental practice in many ways include new radiology technology, cone beam, radiology sensor holders, and aiming devices, caries detection devices, and newer treatment options including ultrasonic tips, caries varnishes, polishing agents, whitening agents, and local anesthetic formulations."

Among the advances that facilitate hygiene treatment, she says, is the DENTSPLY Professional product Oraqix®, a needle-free topical anesthetic product used during scaling and root planing (SRP) for early periodontal disease. "This product is unique in the dental market, as it is the only FDA-approved topically applied anesthetic for the use during SRP procedures. Because of its amide formulation and its eutectic nature, it can aid the clinician with pain management for the patient with early gingivitis and periodontal disease," Johnson explains. According to the product literature, Oraqix combines lidocaine (2.5%) and prilocaine (2.5%) with a unique thermosetting system to deliver pain relief where it's needed. Combining both of these amides into a single treatment provides dual benefits that are important for creating an appropriate anesthetizing effect—fast onset and a duration that should be long enough to work for the entire treatment. And because it it is site-specific, multiple areas of the mouth can be treated in one visit, enabling full-mouth procedures.

Johnson says that DENTSPLY is committed to clinician education and has many supportive educational training opportunities, including a team of Clinical Educators, such as herself, who cover the United States and the international market to assist clinicians in implementing effective and efficient evidence-based treatment protocols—including proper use of its products—in their clinical practices. "The CE Team provides many programs to educate the clinician. We also have a website with instructional videos to walk the clinician through these procedures utilizing our vast portfolio of dental products," she says.

Looking to the future in terms of dental disease prevention, Johnson sees a greater emphasis on the relationship between oral and overall health. "The true wave of the future in dental disease prevention," she concludes, "lies in educating the clinician on the patient's systemic links along with supportive assessment protocols."

Important Risk Information

Oraqix is not for injection. Oraqix is contraindicated in patients who are hypersensitive to local anesthetics. Oraqix should not be used in patients with congenital or idiopathic methemoglobinemia.

Please refer to brief summary of prescribing information on adjacent page before using Oraqix.

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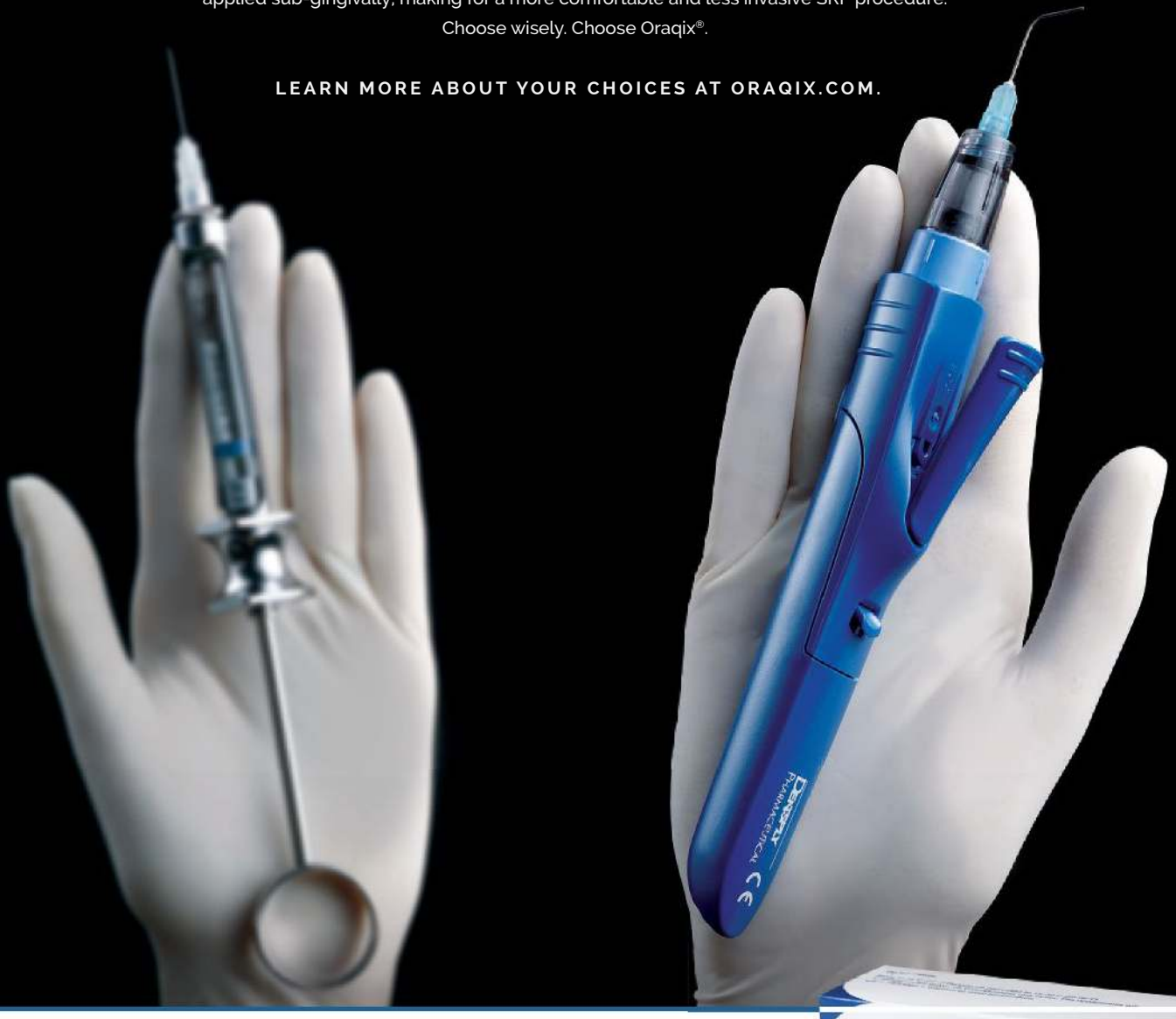

Oraqix® is not for injection. Oraqix® is contraindicated in patients who are hypersensitive to local anesthetics. Oraqix® should not be used in patients with congenital or idiopathic methemoglobinemia. Most common adverse reactions (incidence >15%) are application site reactions including pain, soreness, irritation, numbness, ulcerations, vesicles, edema, abscess and/or redness. Oraqix® should be used during pregnancy only if the benefits outweigh the risks.

Please see Brief Summary of Prescribing Information on the adjacent page.

For more information, call 1.800.989.8826

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INDICATIONS AND USAGE

Oraqix® is an amide local anesthetic indicated for adults who require localized anesthesia in periodontal pockets during scaling and/or root planing.

CONTRAINDICATIONS

Oraqix® is contraindicated in patients with a known history of hypersensitivity to local anesthetics of the amide type or to any other component of the product.

WARNINGS

Prilocaine can cause elevated methemoglobin levels particularly in conjunction with methemoglobin-inducing agents. Methemoglobinemia has also been reported in a few cases in association with lidocaine treatment. Patients with glucose-6-phosphate dehydrogenase deficiency or congenital or idiopathic methemoglobinemia are more susceptible to drug-induced methemoglobinemia. Oraqix® should not be used in those patients with congenital or idiopathic methemoglobinemia and in infants under the age of twelve months who are receiving treatment with methemoglobin-inducing agents. Signs and symptoms of methemoglobinemia may be delayed some hours after exposure. Initial signs and symptoms of methemoglobinemia are characterized by a slate grey cyanosis seen in, e.g., buccal mucous membranes, lips and nail beds. In severe cases symptoms may include central cyanosis, headache, lethargy, dizziness, fatigue, syncope, dyspnea, CNS depression, seizures, dysrhythmia and shock. Methemoglobinemia should be considered if central cyanosis unresponsive to oxygen therapy occurs, especially if metHb-inducing agents have been used. Calculated oxygen saturation and pulse oximetry are inaccurate in the setting of methemoglobinemia. The diagnosis can be confirmed by an elevated methemoglobin level measured with co-oximetry. Normally, metHb levels are <1%, and cyanosis may not be evident until a level of at least 10% is present. The development of methemoglobinemia is generally dose related. The individual maximum level of metHb in blood ranged from 0.8% to 1.7% following administration of the maximum dose of 8.5 g Oraqix®.

Management of Methemoglobinemia: Clinically significant symptoms of methemoglobinemia should be treated with a standard clinical regimen such as a slow intravenous infection of methylene blue at a dosage of 1-2 mg/kg given over a five minute period.

Patients taking drugs associated with drug-induced methemoglobinemia such as sulfonamides, acetaminophen, acetanilide, aniline dyes, benzocaine, chloroquine, dapsone, naphthalene, nitrates and nitrites, nitrofurantoin, nitroglycerin, nitroprusside, pamaquine, para-aminosalicylic acid, phenacetin, phenobarbital, phenytoin, primaquine, and quinine are also at greater risk for developing methemoglobinemia. Treatment with Oraqix® should be avoided in patients with any of the above conditions or with a previous history of problems in connection with prilocaine treatment.

PRECAUTIONS

General: **DO NOT INJECT** Oraqix® should not be used with standard dental syringes. Only use this product with the Oraqix® blunt-tipped applicator. Allergic and anaphylactic reactions associated with lidocaine or prilocaine in Oraqix® can occur. These reactions may be characterized by urticaria, angioedema, bronchospasm, and shock. If these reactions occur they should be managed by conventional means.

Oraqix® coming in contact with the eye should be avoided because animal studies have demonstrated severe eye irritation. A loss of protective reflexes may allow corneal irritation and potential abrasion. If eye contact occurs, immediately rinse the eye with water or saline and protect it until normal sensation returns. In addition, the patient should be evaluated by an ophthalmologist, as indicated.

However, Oraqix® should be used with caution in patients with a history of drug sensitivities, especially if the etiologic agent is uncertain.

Patients with severe hepatic disease are at greater risk of developing toxic plasma concentrations of lidocaine and prilocaine.

Information for Patients: Patients should be cautioned to avoid injury to the treated area, or exposure to extreme hot or cold temperatures, until complete sensation has returned.

Drug Interactions: Oraqix® should be used with caution in combination with dental injection anesthesia, other local anesthetics, or agents structurally related to local anesthetics, e.g., Class 1 antiarrhythmics such as tocainide and mexiletine, as the toxic effects of these drugs are likely to be additive and potentially synergistic.

CARCINOGENESIS, MUTAGENESIS, IMPAIRMENT OF FERTILITY:

Carcinogenesis - Long-term studies in animals have not been performed to evaluate the carcinogenic potential of either lidocaine or prilocaine. Chronic oral toxicity studies of o-toluidine, a metabolite of prilocaine, have shown that this compound is a carcinogen in both mice and rats. The tumors associated with o-toluidine included hepatocarcinomas/ adenomas in female mice, multiple occurrences of hemangiosarcomas/hemangiomas in both sexes of mice, sarcomas of multiple organs, transitional-cell carcinomas/papillomas of urinary bladder in both sexes of rats, subcutaneous fibromas/fibrosarcomas and mesotheliomas in male rats, and mammary gland fibroadenomas/adenomas in female rats. These findings were observed at the lowest tested dose of 150 mg/kg/day or greater over two years (estimated daily exposures in mice and rats were approximately 6 and 12 times, respectively, the estimated exposure to o-toluidine at the maximum recommended human dose of 8.5g of Oraqix® gel on a mg/m2 basis). Complete conversion of prilocaine to its metabolite o-toluidine on a molar basis is assumed. This gives a conversion on a weight basis of about 50% for prilocaine base (dependent on the molecular weights, i.e. 220 for prilocaine base and 107 for o-toluidine).

Mutagenesis - o-Toluidine, metabolite of prilocaine, was positive in Escherichia coli DNA repair and phage-induction assays. Urine concentrates from rats treated orally with 300 mg/kg o-toluidine were mutagenic to Salmonella typhimurium in the presence of metabolic activation. Several other tests on o-toluidine, including reverse mutations in five different Salmonella typhimurium strains with or without metabolic activation, and single strand breaks in DNA of V79 Chinese hamster cells, were negative.

USE IN PREGNANCY:

Teratogenic Effects: Pregnancy Category B
There are no adequate and well-controlled studies in pregnant women. Because animal reproduction studies are not always predictive of human response, Oraqix® should be used during pregnancy only if the benefits outweigh the risks.

Nursing Mothers: Lidocaine and, possibly, prilocaine are excreted in breast milk. Caution should be exercised when Oraqix® is administered to nursing women.

Pediatric Use: Safety and effectiveness in pediatric patients have not been established. Very young children are more susceptible to methemoglobinemia. There have been reports of clinically significant methemoglobinemia in infants and children following excessive applications of lidocaine 2.5% topical cream (See WARNINGS).

Geriatric Use: In general, dose selection for an elderly patient should be cautious, usually starting at the low end of the dosing range, reflecting the greater frequency of decreased hepatic, renal, or cardiac function, and of concomitant disease or other drug therapy.

ADVERSE REACTIONS

A causal relationship between the reported adverse reactions and Oraqix® could neither be established nor ruled out.

Following SRP treatment with Oraqix® in 391 patients, the most frequent adverse events were local reactions in the oral cavity. These events, which occurred in approximately 15% of patients, included pain, soreness, irritation, numbness, vesicles, ulcerations, edema and/or redness in the treated area. Of the 391 patients treated with Oraqix®, five developed ulcerative lesions and two developed vesicles of mild to moderate severity near the site of SRP. In addition, ulcerative lesions in or near the treated area were also reported for three out of 168 patients who received placebo. Other symptoms reported in more than one patient were headache, taste perversion, nausea, fatigue, flu, respiratory infection, musculoskeletal pain and accident/injury.

OVERDOSAGE

Local anesthetic toxicity emergency: If other local anesthetics are administered at the same time as Oraqix, e.g. topically or by injection, the toxic effects are thought to be additive and could result in an overdose with systemic toxic reactions. There is generally an increase in severity of symptoms with increasing plasma concentrations of lidocaine and/or prilocaine. Systemic CNS toxicity may occur over a range of plasma concentrations of local anesthetics. CNS toxicity may typically be found around 5000 ng/mL of lidocaine, however a small number of patients reportedly may show signs of toxicity at approximately 1000 ng/mL. Pharmacological thresholds for prilocaine are poorly defined. Central nervous system (CNS) symptoms usually precede cardiovascular manifestations. The plasma level of lidocaine observed after the maximum recommended dose (5 cartridges) of Oraqix® in 11 patients exposed over 3 hours ranged from 157-552 ng/mL with a mean of 284 ng/mL ± 122 SD. The corresponding figure for prilocaine was 53-181 ng/mL with a mean of 106 ± 45 SD.

Clinical symptoms of systemic toxicity include CNS excitation and/or depression (light-headedness, hyperacusis, visual disturbances, muscular tremors, and general convulsions). Lidocaine and/or prilocaine may cause decreases in cardiac output, total peripheral resistance and mean arterial pressure. These changes may be attributable to direct depressant effects of these local anesthetic agents on the cardiovascular system. Cardiovascular manifestations may include hypotension, bradycardia, arrhythmia, and cardiovascular collapse.

Management of Local Anesthetic Emergencies: Should severe CNS or cardiovascular symptoms occur, these may be treated symptomatically by, for example, the administration of anticonvulsive drugs, respiratory support and/or cardiovascular resuscitation as necessary.

DO NOT FREEZE. Some components of Oraqix® may precipitate if cartridges are frozen. Cartridges should not be used if they contain a precipitate.

Do not use dental cartridge warmers with Oraqix®. The heat will cause the product to gel.

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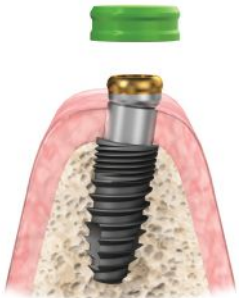

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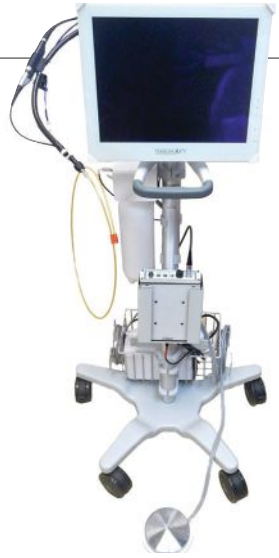

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