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## Contents

### Departments

<table>
<thead>
<tr>
<th>Page</th>
<th>Department</th>
<th>Article</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Editorial</td>
<td>Possibilities and opportunities</td>
</tr>
<tr>
<td>8</td>
<td>Minimally Invasive Dentistry</td>
<td>Minimally invasive biomimetic endodontics: the future is here</td>
</tr>
<tr>
<td>11</td>
<td>Pharmacology</td>
<td>Diet drugs Belviq and Qsymia receive FDA approval: what dentists need to know</td>
</tr>
<tr>
<td>14</td>
<td>Restorative Dentistry</td>
<td>Implant impression techniques including a customized impression tray for nonparallel implants</td>
</tr>
<tr>
<td>17</td>
<td>Prosthodontics</td>
<td>Digital implant impressions and zirconia implant restorations</td>
</tr>
<tr>
<td>20</td>
<td>Ethics</td>
<td>Call of Duty</td>
</tr>
<tr>
<td>77</td>
<td>Oral Diagnosis</td>
<td>Asymptomatic swelling in the floor of the mouth and Asymptomatic nodule in the posterior tongue</td>
</tr>
<tr>
<td>78</td>
<td>Answers</td>
<td>Oral Diagnosis and Self-Instruction Exercises No. 297, 298, 299</td>
</tr>
</tbody>
</table>

### Clinical articles

<table>
<thead>
<tr>
<th>Page</th>
<th>Article</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>Patient Education/Motivation</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Patient Education/Motivation</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Tooth Whitening/Bleaching</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Information Technology/Computers</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Self-Instruction Exercise No. 321</td>
</tr>
<tr>
<td>42</td>
<td>Periodontics</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Dental Materials</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Self-Instruction Exercise No. 322</td>
</tr>
</tbody>
</table>

### Continuing Dental Education (CDE) Opportunities

Earn two hours of CDE credit by signing up for and completing the **SELF-INSTRUCTION** exercises based on various subjects.
52 **Implant materials** Two case reports involving implants and fractured healing caps
  Erdem Kilic, DDS, PhD
  Kerem Kilic, DDS, PhD
  Mustafa Zortuk, DDS, PhD
  Alper Alkan, DDS, PhD

56 **Endodontics** A clinical report of Type III *dens invaginatus*: relevant aspects of a combined therapeutic approach
  Patrícia de Almeida Rodrigues Silva e Souza, DDS, MSc, PhD
  Bruno Vila Nova de Almeida, DDS
  Talita Tartari, DDS
  Ana Claudia Braga Amorosa Alves, DDS, MSc, PhD
  Fabricio Mesquita Tuij, DDS, MSc, PhD
  Mario Honorato Silva e Souza Jr., DDS, MSc, PhD

60 **Periodontics** Obesity and periodontitis: a link
  Charlene B. Krejci, DDS, MSD
  Nabil F. Bissada, DDS, MSD

65 **Pre-Prosthetic Surgery/Partial Dentures** Surgical resection and prosthetic treatment of an extensive mandibular torus
  Thais Marques Simek Vega Goncalves, DDS, MSc
  Jonas Alves de Oliveira, DDS, MSc
  Alfonso Sanchez-Ayala, DDS, MSc
  Renata Cunha Matheus Rodrigues Garcia, DDS, MSc, PhD

69 **Guest editorial** Occlusion confusion
  Gene McCoy, DDS

76 **Self-Instruction Exercise No. 324**

---

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**In the March/April issue of General Dentistry**
- Dental findings in a child with chronic renal failure secondary to cystinosis
- Blood contamination of used dental anesthetic cartridges
- Prevalence and variations of the median maxillary labial frenum in children, adolescents, and adults in a diverse population

**In the February issue of AGD Impact**
- Best marketing strategies for dentists
- AGD 2013 Annual Meeting preview
e2 Prevention/Diet/Nutrition
Five-minute nutrition workup for children in dental practice
S.M. Hashim Nainar, BDS, MDSc

e4 Computer Designed/Fabricated Crowns
Influence of polishing procedures on the surface roughness of dental ceramics made by different techniques
Osmir Batista Oliveira-Junior, DDS, MSc, PhD
Leonardo Buso, DDS, MSc, PhD
Fabio Hiroshi Fujii, DDS, MSc
Geraldo Henrique Leao Lombardo, DDS, MSc
Fernanda Campos, DDS
Hugo Ramalho Sarmento, DDS
Rodrigo Othavio Assuncao Souza, DDS, MSc, PhD

e9 Case Presentations
Vascular leiomyoma in the oral cavity
Janaina Salomon Ghizoni, DDS, MSc, PhD
Eron Martins Baroni, DDS
Eron Jose Baroni, DDS, MSc
Marcelo Tomas de Oliveira, DDS, MSc, PhD
Luís Antonio de Assis Taveira, DDS, MSc, PhD
Jefferson Ricardo Pereira, DDS, MSc, PhD

e12 Case Presentations
Peripheral giant cell granuloma: a case report
Ruchi Banthia, MDS
Shubhra Maheshwari, MDS
Priyank Banthia, MDS
Karan Mantri, BDS, MFDS

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Possibilities and opportunities

Old age has its perks and its distractions. Some people have a tendency to call you Sir or Ma’am, and many even open doors for you. You may have more aches and pains, your hair thins, and new wrinkles constantly appear. Wisdom, patience, and knowledge should be accumulating as you age. You become more forgiving and learn to appreciate each day as a gift. Just as our bodies are changing, so is the world around us; we must be ready to change with the times—or lose out on opportunities.

As Rita Coolidge said, “Too often the opportunity knocks, but by the time we disengage our mental chains, push back the bolt, unhook the locks, and shut off the burglar alarms, it’s too late.” If we see change as a threat, we have a tendency to become defensive, irrational, and prone to discouragement. We go home drained and discouraged because our energies are spent fighting our fear of change and its perceived negative impact. As a result, hundreds of opportunities are lost because our focus is blurred; we become blind to positive prospects.

Change is a natural part of the world. Snakes take change and growth in stride, shedding their skin as they outgrow it. Dentists also need to shed the habits that have outlived their usefulness or inhibit the pursuit of new possibilities.

Loosening our grip on the known and reaching for something in which we believe but of which we are not entirely sure is necessary for survival. Taking risks is central to everything worthwhile in life. Without taking risks, no one would find true love, develop political power, or gain celebrity and prestige. Everything we as humans desire in life involves taking a risk.

It’s a test to let go and enjoy the possibilities each day will bring. I understand how chancy it is for dentists to leap outside the box of status quo. Fortunately, you too can experience how exciting it can be to expose yourself to the unknown—not recklessly, but with calculated enthusiasm—and enjoy all available possibilities. Just think—some of the things that you currently enjoy were once things you were fearful of trying simply because you didn’t want to appear clumsy, inept, or uneducated. Test your limits to prove what you can do, even in a world that seems crazy. Try something new three times—once to get over the fear of doing it, twice to learn how to do it, and a third time to figure out whether or not you like it.

Will fear go away? Probably not. There will be a recurring fear of failure or embarrassment. The fears of rejection, uncertainty, and disappointment will rear their ugly heads, and the fear of difficulty will threaten. The desire for safety will continually tempt you to stop where you are and fall back into the status quo. But don’t let these things stop you.

Win or lose, risk-takers learn to focus on the process as well as the results. We learn to rise above what doesn’t work and find another way to be successful. We see possibilities and opportunities that propel us past the status quo and mediocrity, and experience the challenges of sacrifice and the satisfaction of solutions.

The world is full of wonders, riches, powers, and puzzles, and what it holds can make us horrified, sorrowful, amazed, confused, and joyful. Boredom is the unconscious friend of those who fail to experience the world’s wonders. Don’t become so caught up in your own world that you fail to take advantage of opportunities available to you. Allow security to remain a stranger and risk to become your friend.

As American science fiction writer Ray Bradbury once said, “Living at risk is jumping off the cliff and building your wings on the way down.”

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Minimally invasive biomimetic endodontics: the future is here

Mark Malterud, DDS, MAGD

As mentioned in an earlier column, minimally invasive biomimetic dentistry (MIBD) can reach all aspects of dentistry from preventive care all the way to complex implant restoratives. Most dentists never think of endodontics as fitting solidly into the area of MIBD, but with straight-line access being taught with rotary endodontics, crown down techniques, and conventional hand instrumentation of canals, their eyes have been opened to the amount of tooth structure that is necessary to remove in order to achieve the best straight-line access. Considering the complexity of root canal morphology, none of the above-mentioned techniques seemed to resolve how to best clean, disinfect, and, hopefully, sterilize the canals; therefore, many adjunctive techniques were added, along with chemical intervention and solution activation. Reciprocating handpieces and sonic devices were introduced with the idea of saving precious tooth structure, but these methods didn’t seem to satisfy the problem with extra canals, anastomoses, multiple apical foramina, and lateral canals. Recent articles have been written in peer-reviewed literature describing a new way to effectively remove canal debris from all of these areas with minimal additional instrumentation, utilizing a stripped radial firing Er:YAG laser tip (Fotona D.D.).

This new technology, photon-induced photoacoustic streaming (PIPS), was presented by its developers, DiVito and Colonna, at the World Congress of Minimally Invasive Dentistry meeting in San Francisco, in August, 2009. PIPS technology creates a turbulent 3-dimensional flow of irrigants in the canals. These extremely short bursts of laser energy are directed down into the canals, and the action pumps the tissue debris out of the canals and cleans, disinfects, and sterilizes each main canal to the apex and out into the lateral canals, dentin tubules, and anastomoses. This movement is achieved without the need to place the stripped radial firing laser tip (PIPS tip) into the canal, as with conventional hand and ultrasonic systems; rather, the PIPS tip stays in the coronal aspect of the access preparation only. This allows the clinician to better debride and decontaminate the root canal system without the need to overshape and enlarge the preparation needed for adequate access to the apical one-third. A canal system prepared this way will allow the use of a hydrophilic resin filler system to obturate all the prepared canals, accessory canals, apical foramina, and anastomoses.

In endodontic therapy, dentists who work on root canals have been working nearly blind in a deep, dark hole that has all kinds of nooks and crannies, using only tactile senses to be effective. Studies on root canal success rates range all over the board, depending on if they are multcentered, single site, or single operator, and the parameters describing success vary greatly with all of these studies. These success rates might only relate to patient comfort or how the tissues have appeared to heal with 2-dimensional X-rays, and not indicative of the full removal of debris. Three-dimensional viewing, using cone-beam computerized tomography (CBCT), of the endodontically treated teeth, shows more pathology than has been previously believed. Often, accessory canals, lateral canals, and apices have been missed, and, consequently, organisms capable of reinfection are left behind. Hopefully these organisms have been entombed in the treated teeth and will eventually die, but in many cases all that is needed is an opportunity, such as a “dip” in the patient’s immune system, or loss of a coronal seal, for reinfection to occur. Recent articles in peer-reviewed journals presented protocols using the PIPS technology that demonstrated how this technology virtually sterilizes the root canal system. This new process, along with careful obturation, may cause the success rates exhibited in these studies to climb to even higher levels in future studies.

Since the root forms and canal systems are so varied in size, shape, and patterns, the ability to effectively instrument with conventional systems is nearly impossible. Fig. 1 shows the variation of these canal forms, and the inherent difficulty of trying to reach a file into any one of these lateral canals, the multiple apical openings, and the cross-bridging between the canals. The only way around these canal patterns with conventional root canal treatments (RCTs) is to remove more tooth structure, which thereby weakens the tooth. However, with PIPS technology protocols, the canal systems are cleaned out with the turbulence created by the Er:YAG laser PIPS tip (Fig. 2). Consequently, the canals are left with very bondable surfaces, as shown by scanning electron microscopic (SEM) analysis (Fig. 3 and 4). Fig. 4 not only shows how clean the tooth canal surface is after the PIPS protocols but also offers a view into a lateral canal.
Confocal microscopal studies have validated the effectiveness of the PIPS technique in killing bacteria deep into the dentin tubules and canal systems.10 Extracted teeth, with their canals opened to the outside, were stored in a culture medium of Enterococcus faecalis, which resulted in severely infected surfaces (Fig. 5). A confocal micrograph of the dentinal tubules shows the deep penetration of bacteria (Fig. 6). After the tooth has been put through the entire PIPS protocol, there is nothing notable left on the canal surfaces (Fig. 7). With virtually no biofilm and bioburden left in the intricate canal systems, the tooth can be filled thoroughly with hydrophilic root canal resin filling materials. The canal surface prepared in this way allows for these free-flowing materials to reach deep into the open dentinal tubules and out into lateral canals and apices, sealing the canal system thoroughly. When a tooth has been treated using the PIPS protocol and subsequently filled with hydrophilic resin filling material, a close-up view through the clarified tooth of the fill of the canal systems shows the ability of these procedures to reach deep into areas that cannot be reached by a file. Fig. 8 shows the apex of one of these teeth and illustrates the ability of the PIPS process to open up and fill canals, apices, and lateral canals that used to be either extremely difficult or very time consuming to fill.

Looking at the overall procedures involved in the use of conventional or rotary endodontics, one of the tenets of success has been the ability to get straight-line access of the canals to keep the flex of the rotary instruments to a minimum. These processes remove a significant amount of coronal structure that leaves the tooth weaker and more prone to fracture.11-13 Many new irrigation systems and chemical lavage techniques have been brought to market to help remove the materials from these areas that are not addressed with many of the systems. All of these new processes can be incorporated into the simple process of utilizing a modified Er:YAG laser and the PIPS technique. The actual process of utilizing the PIPS procedure is as follows. First, an anesthetic is delivered to create profound anesthesia to the tooth requiring root canal treatment. The area is carefully isolated with a rubber dam to prevent not only leakage of intraoral fluids into the canal, but also to keep fluids from entering the mouth once they are being activated with the PIPS laser energy. The patient is fitted with laser radiation safety glasses for the prevention of any inadvertent use of the laser and, more importantly, to protect the patient from any splatter of the PIPS-activated solutions.
The tooth is opened to the pulp chamber wide enough to allow access to all the canals with the PIPS tip and also to allow files to be placed to the apex to determine the working length and to locate constrictions. Once the working length is established for all of the canals, the canals can be opened with filing to accommodate a size 20 file at the working length. The PIPS protocol is then initiated to remove debris and sterilize the canals. This procedure is done with low energy levels so that it is virtually subablative. Consequently, the PIPS energy cleans out the canal systems using the acoustic shock and the turbulence created within the canals with these fluids. The first solution to be utilized in the PIPS protocol is sodium hypochlorite (NaOCl). This solution is placed in the pulp chamber and the PIPS tip is activated in the chamber aiming at the canals. High volume suction is utilized to keep the NaOCl and canal debris spatter from reaching areas outside the rubber dam owing to the turbulence of the acoustic shock. Extra NaOCl is syringed into the pulp chamber to replenish the solution that is pulsed out of the access by the PIPS technique. The pulsed energy is utilized for a very specific number of cycles and times using the recommended PIPS protocol.

The NaOCl is evacuated from the canals, the chamber is rinsed with water, and the PIPS tip is activated to remove the leftover NaOCl and canal debris. Once the canal is cleansed out, a chelating agent, EDTA in a fluid form, is placed into the canals and pulp chamber and the PIPS tip is activated again to open up the dentinal tubules to give access to more of the canal anatomy. Once the EDTA has been pulsed, the canal system is rinsed with water and the PIPS tip is activated to remove any remaining EDTA materials so that the tooth can be bonded effectively.

The canal is dried, but not desiccated, with extra-fine paper points, a good quality hydrophilic resin cement root canal filler is placed into the canals, and a gutta-percha point is placed so that the resin can be displaced apically and laterally to help in obturation of the lateral and apical canals as well as the anastomoses within the canal systems.

The PIPS procedure described in this article minimally opens up the coronal aspect of the tooth, then cleans and allows the thorough obturation of the canal system to prevent future issues. This fits well into the MIDB philosophy. MIDB can be included in all areas of dentistry, including endodontics, as shown in this article. The PIPS procedure isn’t the only way to endodontically subscribe to the MIDB philosophy, but this process creates a situation in which very little hard tooth structure is removed and the soft tooth structure is selectively removed along with any pathologic materials that are in the canal system. Lasers are becoming more involved daily in our lives and Er:YAG lasers have a wide range of uses beyond the endodontic procedures described within this article. Future MIDB articles will, over time, include information on the use of lasers as a minimally invasive technique in hard- and soft-tissue applications.

Author information
Dr. Malterud is in general practice in St. Paul, Minnesota. He has lectured and published about minimally invasive dentistry for more than 17 years.

Acknowledgments
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Manufacturer
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The diet drug lorcaserin, known as Belviq (Arena Pharmaceuticals, Inc.) was approved in June 2012, and the diet drug known as Qsymia (active drugs phentermine and topiramate; Vivus Inc.) was approved in mid-July 2012. They were both approved for chronic weight management, as an adjunct to a reduced-calorie diet and increased physical activity, in patients with either an initial body mass index (BMI) of ≥30 kg/m², or an initial BMI of ≥27 kg/m² and at least one weight-related comorbid condition (such as sleep apnea, hypertension, dyslipidemia, or type 2 diabetes). Both of these drugs work through the central nervous system to suppress appetite, by either activating serotonin receptors (Belviq) or enhancing norepinephrine levels (Qsymia).

Previous diet drugs such as fen-phen, the common name for a combination of phentermine (Loramin; still available) and fenfluramine (Pondimin; removed from the US market), as well as Redux (dexfenfluramine; also removed from the US market), were associated with cardiac valvular defects and potential hypertension, and were a source of concern for both medical doctors and dentists. According to the American Heart Association recommendations, dental patients who had formerly used fen-phen “would require prophylactic antibiotic before invasive dental procedures, including oral prophylaxis.” This column reviews the reported adverse reactions caused by Belviq and Qsymia, and if there should be any concerns for dentists and their patients.

**Lorcaserin (Belviq)**

Lorcaserin (Belviq) works through activation of the 5-hydroxytryptamine (5-HT, or serotonin) receptor subtype 2C (5-HT₂C), which decreases food intake through the proopiocortin system of neurons. Lorcaserin is a small molecular agonist of the serotonin 2C receptor that is designed to promote weight loss. Other serotonin receptors have been associated with appetite, such as the 5-HT₁₉ and 5-HT₆ receptors. Previously, fenfluramine, a component of fen-phen, was shown to activate the 5-HT₆ receptors, which resulted in serotonin-associated valvulopathy. Fenfluramine has since been removed from the market. Lorcaserin selectively activates central 5-HT₂C receptors with a selectivity of 15× that of fenfluramine for 5-HT₂A receptors and 100× that of fenfluramine for the 5-HT₆ receptors. According to a report in the *New England Journal of Medicine* in 2010 by Smith et al, a 12-week clinical trial involving obese patients showed that lorcaserin was associated with dose-dependent weight loss without any apparent effects on heart valves. The trial by Smith et al randomly assigned 3,182 obese or overweight adults into 2 groups: one to receive lorcaserin at a dose of 10 mg and the other to receive a placebo, twice daily for 52 weeks. All subjects underwent diet and exercise counseling. At week 52, patients in the placebo group continued to receive placebo, but patients in the lorcaserin group were randomly reassigned to receive either placebo or lorcaserin. Primary outcomes were weight loss at 1 year and maintenance of weight loss at 2 years.

In the Smith et al study, the results at 1 year showed that 47.5% of patients in the lorcaserin group and 20.4% of patients in the placebo group had lost 5% or more of their body weight. Among the patients who received lorcaserin during year 1 and who had lost 5% or more of their baseline weight at 1 year, the loss was maintained in more patients who continued to receive lorcaserin during year 2 (67.9%) than in patients who received placebo during year 2 (50.3%).

Echocardiography was used to identify patients in whom valvulopathy developed. Among the 2,472 patients evaluated at the 1-year and 1,127 evaluated at the 2-year follow-up, the rate of valvulopathy was not increased with the use of lorcaserin. Valvulopathy had developed in 2.7% of patients in the lorcaserin group and 2.3% of patients in the placebo group at year 1. At year 2, the rate of valvulopathy was 2.6% in patients receiving lorcaserin and 2.7% in the placebo group.

Changes in valvular insufficiency scores for the mitral and aortic valves did not differ significantly among the study groups during the trial. No severe mitral or aortic insufficiency was reported. In the study by Smith et al, reported adverse drug reactions in 3% or more of subjects included headache, dizziness, nausea, or dry mouth. The study showed no elevations in blood pressure, nor any increases in heart rate in study subjects.

Smith et al concluded that lorcaserin used in conjunction with behavioral modification was associated with significant weight loss and improved maintenance of weight loss. Lorcaserin caused no significant increase in the incidence of valvulopathy. This observation supports the finding that valvulopathy is not associated with activation of the 5-HT₂C receptor.

**Dental considerations**

At this time there is no information to warrant any precautions in using local anesthetic with vasoconstrictor and no effects or complications have been reported to require any special precautions in dental treatment. Lorcaserin has no reported additive liabilities and is not classified as a controlled substance.

**Qsymia**

Qsymia is the brand name for a combination of phentermine and topiramate in a controlled-release pill taken once a day. Phentermine is a stimulant and topiramate is available as an anti-seizure drug under the brand name of Topamax. Qsymia is supplied in three different dose combinations of phentermine/topiramate: 3.75 mg/23 mg, 7.5 mg/46 mg, and 15 mg/92 mg.
This is the second time that phentermine has been combined with another drug. The first was in the drug fen-phen where it was combined with fenfluramine. This drug was removed from the market due to fenfluramine-associated serious heart valve problems.

Phentermine is a sympathomimetic amine with pharmacologic properties similar to the amphetamines. The mechanism of action in reducing appetite appears to be secondary to central nervous system effects, including stimulation of the hypothalamus to release norepinephrine. The mechanism of action of topiramate on chronic weight management is not known. Labeling states that topiramate causes appetite suppression through a combination of γ-aminobutyric acid (GABA) receptor activity, modulation of voltage-gated channels, inhibition of excitatory glutamate receptors, and inhibition of carbonic anhydrase. Phentermine alone has been on the market since the 1960s and is presently available as a generic drug and under the US brand names of Adipex-P (Teva Pharmaceuticals USA, Inc.) and Suprenza (Alpex Pharma SA) and the Canadian brand name Ionamin (Celltech Pharmaceuticals Inc.).

Qsymia adverse reactions
Qsymia was approved with a designation of a Risk Evaluation and Mitigation Strategy (REMS). This means that both prescribers and patients must be educated about the increased risk of birth defects associated with first-trimester exposure to the drug, along with the need to avoid pregnancy while taking it. Also, the drug will only be dispensed through specially certified pharmacies. Fetal exposure to topiramate has been linked to an increased risk for cleft lip with or without cleft palate. Women who might become pregnant are being advised to use effective birth control while on the drug, and monthly pregnancy tests are also being recommended, along with a negative pregnancy test before starting the medication. Qsymia is listed under FDA Pregnancy Category X, indicating that studies in animals or humans have identified fetal abnormalities associated with the drug. Adverse reactions of Qsymia leading to treatment discontinuation included blurred vision, headache, irritability, dizziness, paresthesia, insomnia, depression, or anxiety. Some postmarketing reports included elevation of blood pressure.

Adverse reactions of interest to dentists
According to its labeling, Qsymia can cause an increase in resting heart rate. A higher percentage of Qsymia-treated overweight and obese adults experienced heart rate increases from baseline of more than 5, 10, 15, and 20 beats per minute compared to placebo-treated overweight and obese adults. The clinical significance of a heart rate elevation with Qsymia treatment is presently unclear. Regular measurement of resting heart rate is recommended for all patients taking Qsymia, and patients should inform health care providers of any palpitations or a rapid heartbeat while at rest. Qsymia does not affect cardiac electrophysiology and does not affect QTc interval. Although Qsymia does not seem to be a risk factor in cardiac arrhythmias, it is not recommended for people with recent or unstable heart disease or stroke. Adverse reactions that were reported more frequently than placebo during first year of treatment (n = 1580) were paresthesia (experienced by ≤20% of patients), dysgeusia (specifically metallic taste, experienced by ≤9% of patients), and dry mouth (experienced by ≤19% of patients). The paresthesia was characterized as tingling in hands, feet, or face, and occurred in 4%, 14%, and 20% of patients treated with Qsymia from lowest to highest doses, respectively. Metallic taste occurred in 1%, 7%, and 9% of patients treated with Qsymia from lowest to highest doses, respectively. Concomitant use of benzodiazepines with phentermine or topiramate may potentiate CNS depression. Qsymia is controlled by Schedule IV of the Controlled Substances Act. The phentermine component has a known potential for abuse. It is related chemically and pharmacologically to the amphetamines. Amphetamines have been widely abused and the possibility of abuse of phentermine should be kept in mind when using Qsymia for weight control.

Fen-Phen
The combination drug fen-phen contained fenfluramine and phentermine. In 1997, fenfluramine was voluntarily withdrawn from the market. The action was based on findings from physicians who evaluated with echocardiograms patients taking fenfluramine. The findings indicated that approximately 30% of patients had abnormal echocardiograms, even though they had no symptoms. Under normal conditions, <1% of patients would be expected to show signs of heart valve disease. The findings suggested that fenfluramine was the likely cause of the heart valve problems. The type of valve damage had only been seen before in persons who were exposed to large amounts of serotonin. Fenfluramine increases the availability of serotonin. The phentermine component was not implicated in the cardiac problem, and therefore was allowed by the FDA to be kept on the market as a single agent.

Phentermine as single agent
As mentioned above, phentermine is also presently available as a single agent under the US brand names Adipex-P and Suprenza and the Canadian brand name Ionomin. It is also generically available. The following information on phentermine can be found on the LexiComp dental drug database. Phentermine can be used as a short-term (a few weeks) adjunct therapy in obese patients with an initial body mass index (BMI) ≥30 kg/m² or ≥27 kg/m² in the presence of other risk factors (including diabetes, hyperlipidemia, and controlled hypertension); therapy should be used in conjunction with a comprehensive weight-management program. Phentermine is a sympathomimetic amine with pharmacologic properties similar to the amphetamines. The mechanism of action in reducing appetite appears to be secondary to the CNS effects, including stimulation of the hypothalamus to release norepinephrine. When taking phentermine, vasoconstrictors should be used with caution. Amphetamines enhance the sympathomimetic response of epinephrine and norepinephrine, leading to potential hypertension and cardiotoxicity.

Adverse reactions of interest to dentists
The key adverse events related to dental treatment in conjunction with phentermine are xerostomia (normal salivary flow resumes upon discontinuation) and unpleasant taste. Hypertension may present in ≤10% of patients.
The proopiomelanocortin system in appetite regulation

Lorcaserin (Belviq) works through activation of the 5-hydroxytryptamine (5-HT, or serotonin) receptor subtype 2C (5-HT_{2C}), which decreases food intake through the proopiomelanocortin system of neurons.² Proopiomelanocortin is a polypeptide within the pituitary gland that acts as the precursor for the production of a group of peptide hormones known as the melanocortins.⁷ The melanocortins exert their effects by binding to and activating the melanocortin receptors. There are at least 5 of these receptors, including MC1R, MC2R, MC3R, MC4R, and MC5R.⁷ The functions of these receptors are modulated by the family of melanocortin peptides. The melanocortin system is involved in a diverse number of physiological functions, including pigmentation, energy homeostasis, inflammation, temperature control, and sexual function.⁸ The MC4R receptor located in the brain appears to be the key melanocortin receptor involved in regulating food intake.⁹ The 5-HT{sub 2C} receptor, when stimulated, promotes a decrease in food intake via activation of MC4R.¹⁰ Lorcaserin appears to suppress appetite by acting at the 5-HT_{2C} receptor to activate MC4R.²

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References


Manufacturers

Alpex Pharma SA, Luzano, Switzerland
091.935.51.10, www.alpex.com
Arenapharmaceuticals, Inc., San Diego, CA
858.453.7200, www.arenapharma.com
Celltech Pharmaceuticals Inc., Rochester, NY
585.475.9000, www.celltechgroup.com
Teva Pharmaceuticals USA, Inc., Wales, PA
888.838.2872, www.tevagenerics.com
UCB-USA, Rochester, NY
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Vivus Inc., Mountain View, CA
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Implant impression techniques including a customized impression tray for nonparallel implants

Bruce W. Small, DMD, MAGD

**Author’s note:** This month’s *Restorative Dentistry* column will be my last as a regularly scheduled columnist in General Dentistry. I have enjoyed sharing information that I sincerely hope has helped some of you over the 15 years that I have been writing this column. It is time to make room for someone else who hopefully will have the same passion for our profession and love of sharing knowledge about excellence in restorative dentistry that I have. Thank you, Academy of General Dentistry, for the honor of allowing me to write this column, and I look forward to continuing to support our organization in every way I can.

Since the middle 1980s when Branemark introduced his “osseointegrated” implant technique to dentistry, more and more implants have been placed by dentists worldwide. Many different types of fixtures, of various shapes and surface treatments, as well as of different connection types, have been introduced over the last 30 years. This month’s column will briefly review both open- and closed-tray impression techniques as well as construction of an impression tray for a multiple-implant case with nonparallel-placed implants.

Open tray vs. closed tray
Open tray and closed tray are the 2 basic methods of taking an impression of an osseointegrated implant. A new, third method has also been introduced (optical or digital impressions), which will be mentioned later.

The open technique uses a tray with a hole or holes for the impression copings to go through that are loosened and removed with the tray. This is also called the pick-up type of impression, as we are picking up the impression copings. The closed method is similar to a crown and bridge impression, utilizing a tray without any opening for the impression copings. A stock or customized tray is placed over the implant and adjacent teeth or tissue and removed. Following removal, the coping is placed back into the impression and a laboratory analog is added prior to pouring the model.

For clinical cases with 3 or fewer implants, the majority of research shows very little difference in the accuracy of open or closed tray techniques. When 4 or more implants are being impressed at the same time, the open tray or pick-up technique results in greater accuracy. In addition, some authors recommend connecting the impression copings with an autopolymerizing resin prior to taking the impression.
By connecting the impression copings, the potential for any unwanted movement is reduced, including leaving 1 of the copings in the mouth. If there is any doubt about the accuracy of the impression, an implant verification jig (Fig. 1) can be constructed on the master model and placed in to check the fit through clinical inspection and radiographs.

Recently, Lee & Gallucci and Ono et al compared digital or optical impression methods and concluded that they were within an “acceptable accuracy range.”6,7 Lee & Gallucci discovered that 60% of study participants preferred the digital impression technique compared to 7% who preferred conventional methods.6

Customized tray construction

A female patient was referred to our office for an implant restorative consultation (Fig. 2 and 3). It was decided to construct two implant-supported bridges on both the right and left maxillary arches following the removal of hopeless teeth No. 5, 11, and 15.

The patient was referred to an oral surgeon, who removed the teeth and, following an appropriate healing time, placed 4 implants. Unfortunately, the 4 implants were not placed parallel to each other, making a closed-tray impression impossible (Fig. 4). Due to the position of the implants, the lack of a mucobuccal fold, and the presence of a few remaining teeth, it was decided to make a customized tray to be used for an open tray (pick-up) impression.

The model was prepared and the differences in angles of the implants were evaluated (Fig. 5). The 2 on the left side were within 10° of each other; therefore, the goal was to have 1 slot for the 2 copings on the left and 2 slots for the 2 copings on the right. The tray would be seated over the left side first, then rotated to the right between the 2 copings present.

A black-tip marker was used on the side of the model to indicate the implant locations (Fig. 6), then a layer of baseplate wax was adapted to the model (Fig. 7). A light-cured custom tray material was draped over the model and cured in the laboratory. Both slots on the left side and the 2 slots on the right side were cut using a carbide acrylic bur (Fig. 8 and 9). The tray was placed and path of insertion checked (Fig. 10 and 11). A small amount of periphery wax was placed around the impression retaining screws to keep impression material out of the holes (Fig. 12).
A few small holes were drilled in the palate area of the tray for relief of the impression material. The tray was coated with an adhesive (Fig. 13) and loaded with a polyether impression material (Fig. 14). The tray was carefully placed over the impression copings, teeth, and edentulous areas, and held until set. The impression retaining screws and the tray were removed (Fig. 15).

**Summary**

The use of implants in restorative dentistry has changed the way many dentists treat patients. Today’s state-of-the-art implants have become the first choice for replacing teeth. Determining which type of impression technique is optimal, and learning how to take an accurate impression increases the success of any implant procedure.

The case report discussed described an open-tray impression technique for nonparallel implants. This concept can be expanded to accommodate additional fixtures if necessary and makes taking of impressions easier for the operator and more tolerable for the patient.

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Dr. Small is in private practice in Lawrenceville, New Jersey, and is an adjunct professor at the University of Medicine and Dentistry of New Jersey. He also is on the Board of Advisors and a visiting faculty member, Pankey Institute, Key Biscayne, Florida.

**References**

Digital implant impressions and zirconia implant restorations

Samuel M. Strong, DDS, DICOI

Digital scans for natural tooth-borne dentistry have been utilized for over a decade by restorative clinicians. Although the market penetration of these digitized impressions has been relatively small, their usage has steadily increased in recent years. These digital images of teeth prepared for crowns and fixed bridges have either been incorporated with in-office milling machines to fabricate the final restoration in 1 appointment or emailed to dental laboratories. In the latter cases, the digital scans of teeth preparations can be converted into working models or these computerized images can be used by themselves, without models, for prosthesis fabrication. This digital scanning technology is now also applied to impressions for dental implant restorations. For this application, a specialized impression coping is placed into the dental implant for the digital image to be captured. The clinician can choose between fabrication of a cement-retained or a screw-retained implant crown from the digital image and model format. In recent years, the potential for entrapment of cement subgingivally around implant crowns has received considerable interest. Minimal submersion below the gingival crest is advocated for the cement-retained implant crown, particularly in the non-cosmetic posterior areas of the maxilla or mandible. Screw-retained implant crown selection can avoid the problems associated with peri-implantitis, bone loss, and possible implant failure due to cement trapped below the gingival crest around implants. In addition, the use of a monolithic zirconia-milled material can provide appropriate fracture resistance for posterior site implant restorations.

Case study
A 17-year-old male with congenitally missing teeth had recently completed a long-term orthodontic treatment. The orthodontist was unable to close all spaces, leaving site No. 12, 13, 20, and 28 vacant as receptive areas for implant placement (Fig. 1). The patient was referred to an oral surgeon for evaluation of the surgical phase for implant placement. A surgical template was fabricated to aid the surgeon in placement of the implants. This appliance was also used as a space maintainer during the implant integration period to prevent teeth adjacent to the implants from moving or collapsing into the edentulous spaces (Fig. 2). Implants (Nobel Replace Internal Tri-channel connection 5.0 mm × 10 mm implants, Nobel Biocare USA, LLC) were placed in the No. 20 and 28 sites by the surgeon. Due to the deficit of available bone and maxillary sinus size, a large bone graft was required in the No. 12 and 13 areas prior to placement of an implant. Therefore, the mandibular implants were integrated and restored prior to the maxillary implant.

Four months after placement, the mandibular implants were torque tested at 35 Ncm with a torque wrench (Nobel Biocare USA, LLC) to confirm their readiness for restoration. An implant-level digital scan impression was procured for the No. 28 site. A standard polyvinyl siloxane (PVS) impression was made of the No. 21 site as a comparison for ease of use. A scan body (Glidewell Laboratories) was connected into the No. 28 site after removal of the healing abutment (Fig. 3). The retaining screw for the scan body was tightened by hand and a radiograph made of the connection.
An iTero digital camera (Align Technology, Inc.) was used to create a digital image of the scan body, adjacent quadrant teeth, and opposing teeth. A digital occlusal bite registration was also procured with the scanning camera (Fig. 4). Upon completion of the in-office digital scanning, the image was sent to an iTero facility, where the image was refined and then sent to a dental laboratory (Glidewell Laboratories).

Our prescription called for the lab to fabricate a screw-retained monolithic zirconia crown (Bruxzir, Glidewell Laboratories) for No. 28. The lab technician designed the implant crown with computer software integrating the iTero digital image. The emergence profile, interproximal contacts, and occlusal surface design were completed on a virtual model by computer (3Shape Dental System, 3SHAPE A/S) (Fig. 4 and 5). The final No. 28 implant crown was then milled, polished, and completed with exterior stain and glaze. The No. 20 implant crown was completed in a different lab using a conventional stone model from the PVS impression and bite registration (Green Dental Laboratory). This crown was also completed as a monolithic zirconia restoration. At the patient’s request, both implant crowns were fabricated in a brighter shade than the adjacent teeth in preparation for an in-office whitening procedure to be done at a later date (Fig. 6).

At the delivery appointment, No. 20 and 28 implant crowns were seated into their respective implants and secured with retaining screws (Fig. 6-8). Periapical radiographs confirmed the complete connection of the crowns to the implant platforms (Fig. 9). Occlusion was checked with articulating paper (AccuFilm, Parkell, Inc.) and shim stock. An implant-protected occlusion was established to allow only the natural teeth to occlude initially on light mandibular closure. The patient also confirmed that his natural occlusal balance was maintained and felt comfortable.

The retaining screws were torqued to the manufacturer’s recommended 35 Ncm (Nobel Biocare USA, LLC). A Teflon (polytetrafluoroethylene, PTFE) tape strip was placed into each occlusal access opening in the screw-retained crowns over the retaining screw head. Light-cured composite was then placed over the PTFE tape sealing the occlusal opening (Fig. 6).

Following sinus-lift grafting and consolidation in the No. 12-13 area, a single implant was placed into the No. 12 site (Nobel Replace Internal Tri-channel connection 4.3 mm × 10 mm implants, Nobel Biocare USA, LLC). The edentulous area was deemed insufficient to restore with 2 standard sized implants and crowns. This condition was thoroughly discussed with the patient.
and his parents. The decision was made to restore the No. 12 site and close the entire area between the implant crown and the No. 14 natural tooth, realizing that the mesial-distal dimensions of the implant crown would be larger than a typical bicuspid restoration. By choosing to restore with a retrievable, screw-retained crown, the interproximal areas could be modified if necessary due to hygienic or esthetic concerns.

Three months after placement of the No. 12 implant, a scan body was placed into the implant and a digital scan procured with the iTero digital camera. The resulting digital image and model were sent to Glidewell Laboratories for fabrication of a screw-retained Bruxzir crown (Fig. 7). The implant crown emergence profile, interproximal contacts, and occlusal surface were designed on the computer and approved for milling of the monolithic zirconia material (Fig. 8). Upon return of the completed restoration to the dental office, the connection into the No. 12 implant was performed. The retaining screw was torqued to 35 Ncm, correct occlusion confirmed, and the screw access opening sealed with Teflon tape and light-cured composite (Fig. 10).

Digital impressions provide yet another method for accurately transferring the implant position to a working master cast or virtual image. The lab technician can then design all aspects of the final restoration prior to milling. This process, combined with the use of monolithic zirconia crown material, provides strength, esthetics, retrievability, and elimination of concerns about cement retention adjacent to the implant crown.

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Green Dental Laboratory, Heber Springs, AR
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Nobel Biocare USA, LLC, Yorba Linda, California
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Parkell, Inc., Edgewood, NY
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45.7027.2620, www.3shape.com
Dr. Miller worked at Community Clinic for 8 years. A practice that serves primarily low income patients, Community Clinic provided Dr. Miller with difficult but rewarding work. The dental needs of the population there were overwhelming, but she felt it was a way to give back to the community. The neighborhood in which the clinic resides had a high crime rate. During her tenure there, it wasn’t unusual to hear of a shooting or other incidents occurring nearby. The staff at the clinic, being very dedicated to their work, took it in stride. For their safety, however, clinic management encouraged staff to walk to and from the building in the company of others, especially in the evening.

One beautiful fall afternoon was unusually slow at the office. Dr. Miller and her colleague, Dr. Gira, were on duty and scheduled to work until 5 pm. At 4:30, a 15-year-old male, Joseph, and his mother walked in. Joseph’s mother, Theresa, stated that Joseph was playing basketball when he was hit in the mouth and his front tooth was knocked out. The dental receptionist processed the new patient paperwork and Joseph and his mother were swiftly escorted into Dr. Miller’s operatory.

Upon hearing the nature of the emergency, Dr. Miller was quick to respond. The clinical exam showed that the maxillary right permanent central incisor was missing and the socket was beginning to heal over. The maxillary anterior frenum was torn but also healing. Joseph’s right cheekbone was bruised and his right eye was black. It was obvious that this injury did not occur that day. The radiographic examination showed no signs of maxillary fracture nor the presence of a root tip in the socket. The tooth was cleanly avulsed.

When questioned about the details of the injury, Theresa and Joseph were very vague with their answers and Dr. Miller suspected they were not being truthful in describing what happened. Theresa finally admitted that the injury occurred two days prior. When asked why they didn’t come in right away, Theresa said she didn’t have time and that Joseph was not in any pain when it happened. In fact, the only reason they came in that day was to “get a new tooth.” They did not have the avulsed tooth with them as they said they could not find it. Joseph would not look Dr. Miller in the eye when answering questions regarding the injury. Joseph was a tall, tough-looking teenager, but he sat slouched in the dental chair looking over strangely at his mother with each answer he gave. Dr. Miller asked Theresa to step out of the room so that she could speak with Joseph alone, thinking he might be more comfortable talking about the injury without his mother there. However, both Theresa and Joseph became very anxious over this request and Theresa refused to leave.

Dr. Miller felt uneasy and believed that Theresa and Joseph were trying to hide something. She also had the feeling that Joseph may have been intentionally punched in the face and that the injury was no accident; his black eye was pretty severe. Dr. Miller’s instinct told her it could possibly be a case of child abuse.

Unsure of exactly how to handle the situation in that moment, Dr. Miller explained the process of making a provisional partial denture for Joseph as an initial treatment option until more definitive treatment could be done. Theresa and Joseph agreed, impressions and a bite registration were taken, and they were dismissed for the day. They were scheduled for the partial delivery in 2 weeks.

After Joseph and Theresa left the office, Dr. Miller’s feelings of uneasiness persisted. Should she just dismiss her suspicions of child abuse or should she call the Department of Child Protective Services (DCPS) and make a report? She weighed her options (Table).

### Relevant facts

As health care providers, dentists not only have the ethical obligation but are also required by law to report suspected cases of child abuse to the proper authorities. Dental professionals are known as mandated reporters. The American Dental Association Principles of Ethics and Code of Professional Conduct (ADA Code) dictates this obligation, as do laws in all 50 states under the Child Abuse Protection Act of 1974.1,2

Making the call is difficult—both diagnostically, as the signs of physical abuse may be hidden, and emotionally, as the dentist must get involved in a patient’s personal life. Abuse comes in all shapes and sizes, so frequently it is not easy to recognize the signs. There are implications to reporting suspected cases of abuse and neglect for the child and the family involved, as well as for the reporting party. Sorting through these issues and making the right call in any given circumstance is the challenge.

Craniofacial, head, oral, and neck injuries are common in cases of child abuse.3,5 In one study of 260 documented cases of child abuse, more than 65% involved such injuries.3 By nature, dentists are in a unique position to recognize abuse and report it. However, less than 1% of reported cases of child abuse are generated by dentists.3 The reasons for this could be:

- the fear of making a false assumption;
- the fear of losing patients;
- the fear of reprisals; or
- being unaware of the obligation to report.7

For fiscal year 2010 in the United States, nearly 700,000 children were confirmed victims of child abuse or neglect.5(p.222) In the same year, over 1500 died as a result of their injuries.5(p.58)
In the current case, the victim may not be considered “typical.” It is not unusual for male teenagers to experience facial injuries from participation in sports or even from having altercations with peers. Joseph, despite his physical size and appearance, is only 15 years old and therefore still a minor; as such, he is entitled to protection from abuse and neglect under the terms mentioned above. It would have been very easy for Dr. Miller to accept that Joseph received a basketball injury and leave it at that. However, it was through thorough history-taking as well as keen observation and diagnostic skills that she was able to detect a potential problem. Each state has its own statutory definition of child abuse, as well as child abuse and neglect reporting statutes. Almost every state statute also has a penalty for failure to report suspected cases. While these statutes may differ slightly in detail, they are similar in content.1

Child abuse is considered an act of commission and is defined as non-accidental injuries or trauma inflicted on a minor child by a parent or other caregiver. Child neglect, as defined in state statutes, refers to acts of omission. Neglect is a failure to provide adequate care, support, nutrition, or medical or surgical care.2,3 In this case, Dr. Miller suspects Joseph of having been abused based on the nature of his injuries and the suspicious manner in which he and his mother were behaving during the course of the dental appointment.

It is important to mention the fact that each state statute provides protection to mandated reporters from civil and criminal liability arising from good faith reports; therefore, it is always best for a dentist, as a mandated reporter, to err on the side of child protection. One only needs to suspect that abuse or neglect has occurred in order to report it. The reporter will then be protected from legal retribution from the accused should they initiate legal action against them. The investigative aspect of the case is then conducted by the agency receiving the report.2,3,6

### Relevant values at play

When the ADA Code addresses this topic, it does so under the principle of Beneficence.1 Under this principle, dentists have the ethical duty to always put the patient’s welfare first. It states:

> The public and the profession are best served by dentists who are familiar with identifying the signs of abuse and neglect and knowledgeable about the appropriate intervention resources for all populations.

> A dentist’s ethical obligation to identify and report the signs of abuse and neglect is, at a minimum, to be consistent with a dentist’s legal obligation in the jurisdiction where the dentist practices. Dentists, therefore, are ethically obliged to identify and report suspected cases of abuse and neglect to the same extent as they are legally obliged to do so in the jurisdiction where they practice. Dentists have a concurrent ethical obligation to respect an adult patient’s right to self-determination and confidentiality and to promote the welfare of all patients. Care should be exercised to respect the wishes of an adult patient who asks that a suspected case of abuse and/or neglect not be reported, where such a report is not mandated by law. With the patient’s permission, other possible solutions may be sought.

> Dentists should be aware that jurisdictional laws vary in their definitions of abuse and neglect, in their reporting requirements and the extent to which immunity is granted to good faith reporters. The variances may raise potential legal and other risks that should be considered, while keeping in mind the duty to put the welfare of the patient first. Therefore a dentist’s ethical obligation to identify and report suspected cases of abuse and neglect can vary from one jurisdiction to another. Dentists are ethically obligated to keep current their knowledge of both identifying abuse and neglect and reporting it in the jurisdiction(s) where they practice.

> It is good for us to be reminded of this ethical obligation mandated by our profession. Its strong language and articulate wording leave nothing to the imagination; dentists must report suspected cases of abuse and neglect notwithstanding.

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### Table. Options available to Dr. Miller.

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<tr>
<th>Option 1</th>
<th>Rationale</th>
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<tr>
<td>Dismiss her suspicions of child abuse. Make the partial denture for Joseph and make no further mention of the injuries.</td>
<td>Joseph was a physically mature teenager and probably able to take care of himself. His injuries, though severe, could have been caused by the basketball game as they stated. Reporting suspected abuse without reasonable grounds for suspicion could result in embarrassment to Joseph and his family and consume a tremendous amount of their time. Dr. Miller also feared for her own safety if she angered Joseph or his family members unnecessarily. They might seek some type of revenge.</td>
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<th>Option 2</th>
<th>Rationale</th>
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<td>Report Joseph’s injuries immediately to DCPS as a possible case of child abuse.</td>
<td>As a dentist, Dr. Miller is a mandated abuse/neglect reporter. Therefore she has to put her patient’s best interest ahead of her own and make that difficult call to DCPS. It is better to err on the side of safety and the patient’s welfare in such cases.</td>
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<th>Option 3</th>
<th>Rationale</th>
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<td>Wait until Joseph comes back for the partial delivery to make a decision on referral to DCPS. Reassess the situation at his next visit.</td>
<td>Joseph and his mother may be more forthright with information at the next visit and Dr. Miller may be able to make a better assessment of the situation. She does not want to jump to conclusions about abuse just yet. The partial denture should be ready in 2 weeks and that is not too long a time to wait to make a more accurate determination of the events. She could call DCPS at that time if she deems it appropriate. However, the lack of intra-oral and extra-oral photographs could jeopardize the reporting process.</td>
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The principle of veracity, or truthfulness, also applies to this case. Dr. Miller had to be honest with herself when examining the evidence. Although she did not want to believe this was actually a case of abuse, all the facts seemed to be pointing in that direction. Joseph and Theresa seemed to not honor veracity here, as Dr. Miller felt they were not being truthful in answering her questions.

Lastly, nonmaleficence, or doing no harm, comes into play. This can be looked at in multiple dimensions. The most obvious aspect of nonmaleficence in this case is the potential harm to Joseph in the future if Dr. Miller chose not to report the suspected abuse and Joseph was indeed an abuse victim. The physical and psychological effects of abuse and neglect on children are horrifying. Also, if this is indeed a case of abuse, who is the abuser? Further harm could come to Joseph or other family members if the abuser is angered by the child abuse investigation. On the other hand, an unwarranted report of child abuse could possibly ruin a good person’s reputation if this information becomes known publically. Dr. Miller may fear for her own safety as well after making the report. The abuser could possibly seek revenge on her if he/she discovers that she initiated the report. Fear of retribution is one of the main reasons abuse goes unreported. 2,3,6

Discussion and postscript

The above scenario is based on a real case. Dr. Miller’s ethical and legal obligation to report any suspected case of child abuse or neglect supersedes any fear of retribution to herself or to Joseph’s family that she may have. Waiting 2 weeks to reassess is too long. A lot could happen during that time in an abusive home. Dr. Miller did indeed decide to call DCPS that day. The DCPS initiated an investigation into Joseph’s case and the report of abuse was substantiated. Joseph was indeed being abused by his stepfather, Jake. Often, Joseph and Jake did not see eye to eye and Jake responded by “punishing” Joseph; he punched him in the face causing the injuries observed by Dr. Miller. It turns out that this was not the first time something like this happened. Theresa felt helpless and was afraid to say or do anything to further upset Jake, so the abuse had continued. Joseph was taken to a safe place, got his provisional partial denture, but was never seen at Community Clinic again.

This case illustrates the fact that dentists need to be aware of the signs and symptoms of abuse and neglect and their ethical and legal obligations to report it. Child abuse can happen in many different ways—physical, sexual, and emotional, as well as by neglect. The following are common possible indicators of child abuse: displaced or avulsed teeth, bruising of the hard or soft palate, oral lesions of sexually transmitted diseases, pregnancy, black eyes, broken bones, bruises at different stages of healing, head injuries, cigarette or immersion burns, human bite marks, being dressed inappropriately for the weather, failure to make eye contact, displaying a fear of being touched, or exhibiting severe anxiety. 4,7,8

Every dentist has a professional duty to become familiar with the statutes of his/her state and its reporting agencies. Making the call is never easy, but it only takes the suspicion of abuse or neglect to trigger the reporting process. Since mandated reporters are protected from litigation when making a good faith referral, one should always err on the side of child protection when making the decision whether or not to call the reporting agency. Dentists must be willing to do their part to help stop the violence and perhaps save a life. Dr. Miller made the right call.

Author information

Dr. Roucka is a fellow of the American College of Dentists, a Navy veteran, and president-elect of the American Society for Dental Ethics. She is also an assistant professor and program director, General Dentistry, Marquette University School of Dentistry, Milwaukee, Wisconsin, where Dr. Gonzalez is a board-certified pediatric dentist, and associate professor and director, Undergraduate Program in Pediatric Dentistry.

References

Increasing antiplaque/antigingivitis efficacy of an essential oil mouthrinse over time: an in vivo study

Christine A. Charles, RDH, BS • J.A. McGuire, MS • James Qaqish, BS • Pejmon Amini, DDS

Financial Disclosure: Two of the authors are employed by Johnson & Johnson Healthcare Products Division of McNeil-PPC Inc., Skillman, New Jersey, makers of Listerine Antiseptic Mouthwash, an essential oils-containing mouthrinse. The remaining two authors are employed by BioSci Research America Inc., an independent clinical research organization in Las Vegas, Nevada.

This randomized, observer-blind, parallel, controlled study determined the efficacy of an essential oils-containing (EO) antiseptic mouthrinse (in conjunction with toothbrushing) in reducing and/or controlling existing plaque or gingivitis over 6 months. Toothbrushing, combined with placebo rinsing, served as the control (C). Following ethics board approval (Biosci Research Canada, Ltd. Institutional Review Board), 139 healthy adults with mild to moderate plaque and gingivitis were randomized into EO or C groups. All subjects received oral/written instructions, monthly monitoring, and assigned unsupervised rinses. Efficacy variables were whole-mouth mean modified gingival index (MGI), Turesky modification of the Quigley Hein plaque index (PI), bleeding index (BI) at 6, 12, and 24 weeks, and data analysis through an analysis of covariance (ANCOVA) model. The EO group provided greater and increasing MGI, PI, and BI reductions than did C group over all examination periods. Compared to the C group, at 6, 12, and 24 weeks, MGI reductions for the EO group were 4.7%, 9.1%, and 20.4%, and PI reductions were 7.6%, 12.6%, and 26.3%, respectively. BI scores decreased over time and were significant compared to those for the C group (\(P < 0.001\)). Additionally, the percentages of sites improved versus baseline MGI over time for EO were 14.1%, 26.4%, and 43.3%, respectively. This study demonstrated that an EO-containing mouthrinse can provide an increasing benefit over a period of 6 months with twice daily use. This study also confirmed that an antiseptic EO rinse can provide a clinically significant benefit in reducing existing plaque and gingivitis.

Accepted: July 26, 2012

Adequate control of plaque biofilm is essential to prevention and control of periodontal diseases, dental caries, and the patient’s oral health. Given the prevalence of these diseases globally—with caries in 60%-90% of children, gingivitis in up to 80% of the populations in developed countries, and periodontitis in 50% of global populations—it would seem that mechanical oral hygiene procedures alone are not practiced sufficiently by a majority of the population. This lack of sufficient oral hygiene provides a rationale for implementing additional means of improving oral hygiene.

Mechanical oral hygiene techniques, such as toothbrushing, generally focus only on the teeth, which comprise about 25% of the oral surfaces. Antiseptic mouthrinses, by virtue of their liquid nature, reach nearly 100% of oral surfaces. Plaque bacteria are prevalent on the oral mucosal tissues that comprise the majority of the oral surface, which provide reservoirs for bacteria to recolonize on the tooth surfaces. Daily rinsing with an effective antimicrobial mouthwash may help to reduce the total microbial burden in the oral cavity, thereby contributing to better oral hygiene.

Efficacy in plaque and gingivitis reduction resulting from use of antimicrobial mouthrinses—that is, mouthrinses containing chemotherapeutic agents such as chlorhexidine, cetylpyridinium chloride, and essential oils (EO)—has been demonstrated in both short-term experimental gingivitis models that do not utilize mechanical oral hygiene and in 6-month clinical trials utilizing the ADA Council on Scientific Affairs’ Acceptance Program Guidelines: Chemotherapeutic Products for Control of Gingivitis (2008).

In two 6-month trials where a regimen of toothbrushing and daily flossing (BF) was compared to a regimen of toothbrushing, daily flossing, and rinsing (BFR) with an EO-containing mouthrinse, the BFR group demonstrated a statistically and clinically significant advantage in both plaque reduction (up to 51.9%) and gingivitis reduction (up to 21%) compared to the BF group (\(P < 0.001\)). Both plaque and gingivitis were also reduced—by up to 56.3% and 29.9%, respectively—compared to a brushing alone group at 6 months (\(P < 0.001\)). BF provided an advantage to brushing alone by up to 11.2% (\(P < 0.001\)). In most of the referenced 6-month trials, a dental prophylaxis was included in the clinical study design at the initiation of the study and a greater benefit was provided at 6 months than at 3 months.

Since it has been shown that regular professional care and a regimen of brushing, flossing, and rinsing with an antimicrobial EO rinse can provide a clinically meaningful improvement in oral health, the objective of this study was to evaluate only the effect of daily usage of an antimicrobial EO-containing mouthrinse (Listerine, Johnson & Johnson) on reducing existing dental plaque and gingivitis over the course of 6 months without an initial prophylaxis, and to determine if there would be an increasing benefit over this period of time, including an earlier evaluation at 6 weeks.

Materials and methods
A randomized, controlled, observer-blind, parallel-group, 6-month clinical trial was conducted in accordance with ADA Acceptance Program Guidelines on Chemotherapeutic Products for Control of Gingivitis and standard operating procedures that comply with the International Conference on Harmonisation’s Good Clinical Practice (ICH GCP) guidelines. The clinical protocol, including informed consent procedures that comply with the International Conference on Harmonisation’s Good Clinical Practice (ICH GCP) guidelines.
Increasing antiplaque/antigingivitis efficacy of an essential oil mouthrinse over time

Chart 1. Study flow diagram.

<table>
<thead>
<tr>
<th>Enrollment</th>
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<table>
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<th>Allocated to C intervention (n = 70)</th>
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<tr>
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<td>Allocated to EO intervention (n = 69)</td>
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<td>Discontinued intervention (personal reasons) (n = 3)</td>
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<td>Lost to follow-up (n = 2)</td>
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<td>Discontinued intervention (personal reasons) (n = 1)</td>
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<td>Completed (n = 66)</td>
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<tr>
<td></td>
<td>ITT (n = 66)</td>
</tr>
<tr>
<td></td>
<td>Evaluate (n = 65)</td>
</tr>
</tbody>
</table>

*There were 67 subjects in the ITT group at 6 weeks, but only 66 completed the study at 6 months.

consent, was reviewed and approved by an institutional review board, and the study was conducted at BioSci Research America in Las Vegas, Nevada. All subjects read and signed an informed consent form prior to the start of this study.

Subjects refrained from oral hygiene for at least 8 hours, but no more than 18 hours, prior to the baseline examination. The oral examination included hard and soft tissue assessment and scoring of gingival, bleeding, and plaque clinical indices by a trained and calibrated dental examiner who demonstrated repeatability (R ≥ 0.90) in the indices utilized. Gingivitis was assessed using the MGI at 4 sites (the buccal and lingual marginal gingivae and interdental papillae) of all scorable teeth and scored on a 5-point scale where 0 = normal (absence of inflammation); 1 = mild inflammation (slight change in color, little change in texture) of any portion of the gingival unit; 2 = mild inflammation of the entire gingival unit; 3 = moderate inflammation (moderate glazing, redness, edema, and/or hypertrophy) of the gingival unit; and 4 = severe inflammation (marked redness and edema/hypertrophy, spontaneous bleeding, or ulceration) of the gingival unit.21 BI was assessed using a periodontal probe with a 0.5 mm diameter tip inserted into the gingival crevice and swept from distal to mesial, around the tooth at an angle of approximately 60° while in contact with the sulcular epithelium.22,23 Each of the four gingival sites (distobuccal, midbuccal, midlingual, and mesiolingual) around each tooth was assessed. After approximately 30 seconds, bleeding at each gingival unit was recorded according to the following scale: 0 = absence of bleeding after 30 seconds, 1 = bleeding after 30 seconds, and 2 = immediate bleeding.

Following disclosing, the plaque area was scored using the PI on 6 surfaces (Soparkar modification), mesial, middle, and distal surfaces on the facial and lingual aspects of all scorable teeth and scored on the following scale: 0 = no plaque; 1 = separate flecks or discontinuous band of plaque at the gingival (cervical) margin; 2 = thin (up to 1 mm), continuous band of plaque at the gingival margin; 3 = band of plaque wider than 1 mm, but less than one-third of surface; 4 = plaque covering one-third or more, but less than two-thirds of surface; and 5 = plaque covering two-thirds or more of surface.24,25

All subjects were required to have a whole-mouth mean MGI > 1.75 and PI > 1.95 at baseline to qualify for the study. A total of 139 healthy volunteers with mild to moderate levels of plaque and gingivitis were enrolled in the study. Following the baseline examinations, all qualified subjects were randomized into 2 groups and instructed to brush twice daily with an ADA-accepted toothbrush (Oral-B 35, Proctor & Gamble) and a fluoride dentifrice (Colgate MFP, Colgate-Palmolive Company).

Subjects were instructed to rinse morning and evening with their assigned mouthrinse, either a hydroalcohol negative control rinse (C) or an EO-containing mouthrinse.

Oral and written instructions were provided to subjects. Daily rinsing was unsupervised, with the exception of the initial visit. All subjects were instructed to brush thoroughly twice daily and were provided with a toothbrush and dentifrice as needed. All subjects were instructed to rinse for 30 seconds with 20 ml of the EO or C rinse full strength, morning and night, to standardize twice daily usage consistent with marketed product label directions. All subjects were provided 1oz plastic dosage cups with the 20 ml level marked. They were allowed their usual dietary habits, but instructed to refrain from using any oral care products other than what was provided to them for the duration of the study. Use of dental floss or other interdental devices was allowed as needed to remove food debris. Subjects returned at monthly intervals for compliance evaluation, replenishment of test materials, and adverse event monitoring.

A dentist, trained and calibrated in the clinical indices, performed all study examinations. Care was taken to minimize bias and guarantee the blindness of the study by using rinses that were the same color and identical bottles that were individually labeled by subject number. The dental examiner and recorder were totally separated from distribution and handling of rinses. Prior to the 6-, 12-, and 24-week examinations, subjects refrained from use of all test products for at least 8 hours prior to the examination so as not to introduce any telltale rinse odor to the examiner. In addition, product dispensing...
personnel did not participate in the examination of subjects.

**Statistical methods**
The primary efficacy variables were whole-mouth mean MGI and mean PI at 6 months (24 weeks). Secondary variables were whole-mouth mean MGI and PI at 6 weeks and 12 weeks and mean BI at 6, 12, and 24 weeks.

Statistical comparisons for primary and secondary variables were based on the ANCOVA model with treatment as a factor and the corresponding baseline value as a covariate. For each variable, treatment groups were compared at the 0.05 level, two-sided. The primary analysis for each variable was based on intent-to-treat (ITT) subjects, defined as all randomized subjects who used at least 1 dose of study mouthrinse and had data for mean MGI or mean PI at post-baseline. Secondary analyses were based on data from evaluable subjects, defined as ITT subjects with no major protocol violations. Summary statistics were provided by treatment group.

The planned sample size of 100 (50 per treatment group) completed subjects was based on data from previous studies. Using the 6-month data from these studies, the standard deviations were conservatively estimated to be 0.27 for mean MGI and 0.50 for mean PI. Based on these estimates, a sample size of 50 per treatment group provides 90% power to detect a difference in treatment means of 0.29 for mean MGI and 90% power to detect a difference of 0.36 for mean PI. These differences represented 15% reductions from the estimated placebo mean in the previous studies.

**Results**

**Population**
A total of 139 subjects were randomized into 2 treatment arms, 70 to the C group and 69 to the EO group. Seven subjects discontinued the study, with 66 ITT subjects in the C group and 66 in the EO group completing the study (Chart 1).

Subjects ranged in age from 18 to 61 years old with a mean of 30.9 years. There were 61 (43.9%) male and 78 (56.1%) female subjects. Approximately half were white (49.6%) and the majority had never smoked (79.9%). Treatment groups were balanced with respect to all baseline characteristics (Table 1).

**Safety**
The safety analysis was based on all randomized subjects. One subject withdrew from the study due to an issue not related to the study. There were only 2 subjects with at least 1 adverse event in each group representing 2.9% of the groups. The adverse events were considered unrelated to study treatment. The mouthrinse treatments were well tolerated by the subjects.

**Efficacy**
Chart 2 presents whole-mouth mean scores for PI and MGI for ITT subjects. Results for evaluable subjects were consistent with those for ITT subjects, therefore only ITT data is presented. This figure provides mean scores at each examination period for the 2 primary variables in the study, plaque and gingivitis.

Plaque Index: PI scores were statistically significantly lower for the EO group compared to the control group. The chart shows a significant reduction in PI scores over the 6-month period for subjects using the EO mouthrinse compared to those using the placebo.

Gingival Index: The modified gingival index (MGI) also showed a reduction in inflammation for the EO group. The chart illustrates the mean MGI scores for each treatment group at different time points, with a notable decrease in MGI scores for the EO group compared to the control group.

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**Table 1. Demographic characteristics of subjects in study.**

<table>
<thead>
<tr>
<th></th>
<th>Control (n = 70)</th>
<th>EO rinse (n = 69)</th>
<th>Total (N = 139)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>30.6 ± 11.07</td>
<td>31.3 ± 9.30</td>
<td>30.9 ± 10.20</td>
</tr>
<tr>
<td>Gender, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>32 (45.7%)</td>
<td>29 (42.0%)</td>
<td>61 (43.9%)</td>
</tr>
<tr>
<td>Female</td>
<td>38 (54.3%)</td>
<td>40 (58.0%)</td>
<td>78 (56.1%)</td>
</tr>
<tr>
<td>Race, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>38 (54.3%)</td>
<td>31 (44.9%)</td>
<td>69 (49.6%)</td>
</tr>
<tr>
<td>Black</td>
<td>11 (15.7%)</td>
<td>19 (27.5%)</td>
<td>30 (21.6%)</td>
</tr>
<tr>
<td>Asian</td>
<td>5 (7.1%)</td>
<td>5 (7.2%)</td>
<td>10 (7.2%)</td>
</tr>
<tr>
<td>Other</td>
<td>16 (22.9%)</td>
<td>14 (20.3%)</td>
<td>30 (21.6%)</td>
</tr>
<tr>
<td>Smoker, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ex-smoker</td>
<td>6 (8.6%)</td>
<td>5 (7.2%)</td>
<td>11 (7.9%)</td>
</tr>
<tr>
<td>Never smoked</td>
<td>54 (77.1%)</td>
<td>57 (82.6%)</td>
<td>111 (79.9%)</td>
</tr>
<tr>
<td>Smoker</td>
<td>10 (14.3%)</td>
<td>7 (10.1%)</td>
<td>17 (12.2%)</td>
</tr>
</tbody>
</table>

Note: There were no significant differences between groups for any variables (P < 0.38).
than for the C group at 6, 12, and 24 weeks ($P < 0.001$) with percent reductions for EO versus C of 7.6%, 12.6%, and 26.3%, respectively.

A site-based analysis of the plaque data provides 20.4%, 32.1%, and 51.4% of sites improved (or lower plaque score) compared to baseline for the EO group at 6, 12, and 24 weeks respectively. In comparison, the C group demonstrated 10.8%, 14.5%, and 11.5% improvement from baseline scores at 6, 12, and 24 weeks, respectively, showing a relatively consistent result over time.

Gingivitis Index: Whole-mouth MGI scores were statistically significantly lower for the EO group than for the C group ($P < 0.001$) with increasing reductions of 4.7%, 9.1%, and 20.4% at 6, 12, and 24 weeks, respectively. Using a site-based approach, the percent of sites improved for MGI was 14.1%, 26.2%, and 43.5% for the EO group and 8.6%, 12.6%, and 12.5% for the C group at 6, 12, and 24 weeks, respectively.

The percentage of subjects experiencing any improvement in gingivitis (based on reduction in mean MGI score) from baseline was 75.8%, 90.9%, and 98.5% in the EO group and 17.9%, 53%, and 30.3% in the C group at 6, 12, and 24 weeks, respectively. At 6 months, nearly 100% of subjects had an improved gingivitis score in the EO rinse group compared to 30.3% in the C group. To further illustrate this improvement in gingival health, Charts 3 and 4 provide the percentage of subjects with an MGI score of 0 or 1 at each site scored in the maxillary and mandibular facial regions after 6 months. This site-by-site view helps to demonstrate the additive effect that an EO antimicrobial rinse can provide beyond toothbrushing in achieving a greater incidence of healthy sites (sites where ≥ half of the subjects achieved a 0 or 1 MGI score). It is interesting to note that the marginal sites (noninterproximal sites for the EO rinse showed better results (Charts 3 and 4). The combination of better mechanical removal and antimicrobial rinsing...
provided a greater incidence of “healthy” sites as shown by the picket fence image of the site-based results beginning on the left with the buccal of tooth No. 2 followed by the papilla then buccal of tooth No. 3 followed by the papilla and so on ending with buccal of tooth No. 15.

Bleeding Index: Table 2 summarizes the BI results by providing mean scores and transitions of scores. The EO group showed statistically significantly lower bleeding index than the control group at 6, 12, and 24 weeks (P < 0.001). Using the site-based analysis transition of scores (Table 2), the EO group demonstrated 4.5%, 7.3%, and 9% sites improved, while the C group experienced 2.9%, 4.3%, and 5.6% sites improved at 6, 12, and 24 weeks, respectively. In the C group, approximately 5% of sites worsened at 6 months as compared to only 2% in the EO group. The majority of sites remained unchanged for bleeding status over the course of the study.

Discussion

The goal of oral hygiene care is to achieve plaque control and healthy gingiva. The results from this study add to the published data, confirming the benefit of regular and consistent daily use of an essential oils-containing antimicrobial mouthrinse in reducing existing plaque and gingivitis and in demonstrating an increasing advantage with regular and consistent twice-daily use over the course of 6 months.26 Considering there was no dental prophylaxis at the initiation of this study, it is interesting to note the continued reduction in plaque scores over time.

Adding an antimicrobial rinse to daily brushing provides an additional means of controlling the plaque biofilm, since the average time spent brushing is approximately 46 seconds, only 2%-10% of patients floss regularly and effectively, and most cannot or will not floss on a daily basis.27,28 A recent systematic review concluded: “There is some evidence from 12 studies that flossing in addition to toothbrushing reduces gingivitis compared to toothbrushing alone. There is weak, very unreliable evidence from 10 studies that flossing plus toothbrushing may be associated with a small reduction in plaque at 1 and 3 months.”29

Even with regular brushing and flossing, bacteria may be left behind in hard-to-reach areas. Antimicrobial mouthrines reduce the bacterial count and stop bacterial activity in the dental plaque that can lead to gingivitis, which is quite prevalent in most adults.30,31

Rinsing with an antimicrobial rinse reduces the overall oral microbial load by up to 99.9% immediately after rinsing, as shown by an analysis of salivary samples for total microorganisms that measures ATP bioluminescence or colony forming units (CFU/ml) indicating presence of bacteria.32 Fine et al reported that 1) the in vivo antimicrobial effectiveness of an EO-containing mouthrinse 12 hours after a single use and after 14-day use can have long-lasting effects in reducing anaerobic bacteria overall as well as Gram-negative anaerobes and volatile sulfur compound (VSC)-producing bacteria, 2) that significant reduction of these bacteria plays a key role in explaining the EO rinse’s effectiveness in reducing supragingival plaque and gingivitis, and 3) consistent twice daily rinsing with an antimicrobial rinse such as an EO rinse that penetrates the plaque biofilm provides a mechanism for reducing the total microbial load and plaque scores, contributing to the reduction in gingivitis.33 In another study, Fine et al demonstrated the effect of rinsing with an EO mouthwash on the properties of developing plaque by measuring limulus lysate activity and concluded that “EO has a dramatic effect on plaque toxic activity as measured by a decrease in limulus lysate assay, as well as on its biomass.”34

This reduction in plaque toxic activity and biomass may contribute to the reduction in gingivitis demonstrated in this and multiple clinical trials of the EO rinse.12,13

In the studies incorporating brushing, daily flossing, and rinsing with an EO rinse, a similar sitewide analysis (as shown in Charts 2 and 3) of the proximal or papillary sites demonstrated that up to 50% of the maxillary sites were considered “healthy” (at least half of the subjects scored 0 or 1 at those sites) compared to none for the toothbrushing plus flossing group or toothbrushing-only group.18-19

Table 2. Whole-mouth bleeding index and site-based transition of scores.

<table>
<thead>
<tr>
<th>Table 2. Whole-mouth bleeding index and site-based transition of scores.</th>
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<tbody>
<tr>
<td>Whole-Mouth Bleeding Index Control EO</td>
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<tr>
<td>Baseline Mean                                   0.10 0.11</td>
</tr>
<tr>
<td>6 Week adjusted mean (S.E.) 0.11 (0.003) 0.08+ (0.003)</td>
</tr>
<tr>
<td>12 Week adjusted mean (S.E.) 0.10 (0.003) 0.06+ (0.003)</td>
</tr>
<tr>
<td>24 Week adjusted mean (S.E.) 0.10 (0.004) 0.04+ (0.004)</td>
</tr>
<tr>
<td>6 Weeks</td>
</tr>
<tr>
<td>n</td>
</tr>
<tr>
<td>Sites improved 188 2.9</td>
</tr>
<tr>
<td>Sites unchanged 5975 93.7</td>
</tr>
<tr>
<td>Sites worsened 213 3.3</td>
</tr>
<tr>
<td>12 Weeks</td>
</tr>
<tr>
<td>n</td>
</tr>
<tr>
<td>Sites improved 277 4.3</td>
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<tr>
<td>Sites unchanged 5744 90.1</td>
</tr>
<tr>
<td>Sites worsened 257 4.0</td>
</tr>
<tr>
<td>24 Weeks</td>
</tr>
<tr>
<td>n</td>
</tr>
<tr>
<td>Sites improved 354 5.6</td>
</tr>
<tr>
<td>Sites unchanged 5599 87.8</td>
</tr>
<tr>
<td>Sites worsened 325 5.1</td>
</tr>
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<td>aP &lt; 0.001 compared to control</td>
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www.agd.org General Dentistry January/February 2013 27
Conclusion

Using an EO-containing mouthrinse provides a clinically meaningful and statistically significant reduction in existing plaque and gingivitis, and provides an increasing incremental benefit to toothbrushing through twice daily use for 6 months. This study confirmed the beneficial effect twice-daily regular use of an EO-containing mouthrinse on existing plaque and gingivitis, with gingivitis reductions within the range of previously reported results.

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References


Manufacturers

Colgate-Palmolive Company, New York, NY 800.2COLGATE, www.colgate.com
Johnson & Johnson, Skillman, NJ 800.690.1826; www.jnj.com
Proctor & Gamble, Cincinnati, OH 513.983.1100; www.pg.com
Paste, wrap, and shimmy: a regimen for the prevention of gum disease

Craig W. Jester, DDS

The body of evidence showing a possible correlation between gum infection and systemic diseases is well documented and growing. At the same time, the prevalence of gum infection is increasing in the general populace. Gum infection and disease are routinely seen in patients who adhere to regular dental hygiene regimens and see their dentists on a regular basis. One of the reasons typical daily dental care does not eradicate gum disease (gingivitis) is that the usual home care regimens do not attack a major underlying cause of gingivitis: the layer of biofilm in the sulcus surrounding the tooth's root. This biofilm harbors and protects the bacteria that cause gum disease and root decay. Research has shown that there are no “magic bullets” in the form of rinses, pills, or special tools that effectively destroy the bacteria and its protective calyx. Therefore, daily dental regimens must be changed until the absence of gum infection and inflammation becomes the standard of care.

Many dental patients exhibit both root decay and gingivitis. These distinct problems frequently occur in tandem. In even the most fastidious people—those who brush and floss twice or more daily—localized areas of gum infection and inflammation can be found. How can this be when these patients are committed to doing what their dentist advises? The reason is that in their cleaning efforts, they miss the area under the cuff of soft tissue—the sulcus or periodontal pocket—that surrounds the base of every tooth (Fig. 1).1 Even in healthy mouths, there is a 1-3 mm space between the gum and tooth that acts as an undisturbed, protected culture tube for bacteria.2 Typical daily dental regimens don't eradicate the layer of biofilm that forms in the sulcus surrounding the tooth's root.3 This biofilm harbors and protects the bacteria that cause gum disease and root decay. Here, according to Schacter, “the bacterial biofilm is in direct contact with host tissues along an ulcerated epithelial interface,” and releases its metabolic byproducts to infect the gum and decay the roots (Fig. 1).4 The most highly organized form of the biofilm occurs after 3 to 12 weeks and is capable of causing the most harmful gum infections.5 Reduced salivary flow (dry mouth) and lowered host resistance also contribute to these infections in the elderly, but all ages are affected. Paquette et al predicted that 75% of the adult population has at least mild gingivitis.6 The author of this article estimates that the number is closer to 95%.

Conventional flossing and brushing do not thoroughly disrupt the organized plaque from the tooth surface (the biofilm attaches to the tooth, not the gum). Many people regularly floss without ever going deeply under this cuff of tissue. They believe their flossing procedure to be incorrect if it causes their gums to bleed; so frequently, the bacteria thrive undisturbed. The biofilm forms an effective protective barrier, a mucopolysaccharide film, which resists rinsing, water jets, ultrasonic brushes, and even harsh antibacterials.7-11

How can patients effectively clean under this cuff of tissue and disrupt the biofilm on the roots without damaging their gums?

Materials and methods

Commercial toothpastes contain an abrasive, which is useful in breaking up the biofilm.12-14 However, for this pumice to be effective, the toothpaste needs to access the tooth surface under the gumline and be carried onto the root. To do this, the patient should begin by using a soft, rounded bristle brush that is dry (saliva will quickly moisten the brush) and loaded with an ADA-approved toothpaste, which can be found at the ADA MouthHealthy Seal Products website (www.mouthhealthy.org/ada-seal-products).15,16

This pumice must be carried onto the root with very short, choppy movements, tooth by tooth, using the ends of the bristles to move the paste and clean the root surfaces from the cheek side and then the tongue side, with the patient lightly biting the back of the brush to sink the bristles under the tissue. The goal is to

Fig. 1. Biofilm in the periodontal pocket. (Illustration courtesy of Dr. Fay Goldstep.)
work around the arch, pushing the pumice down the tooth and under the tissue cuff to clean the root surface (Fig. 2). The brushing can be effectively done with a mechanical or ultrasonic brush as well, but care should be given to hold the brush longer in each area to allow it time to work along the gum line.

After spitting out excess saliva, the patient moves to the second, and more important, part of the routine: flossing the toothpaste under the tissue cuff and onto the roots (Fig. 3). Since the brush bristles will only reach a third of the depth into a healthy sulcus, more root surface can be pumiced with the floss than with the brush. Have the patient apply toothpaste to his/her finger and rub the toothpaste along the base of their teeth on the cheek side, a quarter of the mouth (quadrant) at a time. Reloading of the paste for each quadrant will be necessary, due to the dilution of the toothpaste by the saliva (Fig. 4). Then, wrap 18-24 inches of floss around the last 3 fingers of each hand (with the index fingers and thumbs free), leaving 0.5 in between the opposing fingers (Fig. 5). If the index fingers are further apart than 0.5 in, the floss cannot be properly controlled. Moving their index fingers inside the mouth, the patient should slide the floss through the contact point between the first 2 teeth, wrap the floss around 1 of the teeth and shimmy the toothpaste up and down, 2 to 3 times on the first root, then move to the next tooth—over the mound of gum between the 2 teeth (papillae)—and clean the adjacent root in the same way. The mantra is paste, wrap, and shimmy.

In between each set of tooth contacts, the patient should push forward when wrapping around 1 root and pull back in order to wrap around the next tooth. The patient should pumice 2 roots in each interdental space, and then release 1 end of the floss and pull it through rather than popping up through the contact and doing any damage to crowns, inlays, or fillings. The patient should work his/her way down the quadrant. Thoroughness is the key.

All commercial toothpastes have 3 important ingredients: a pumice, a bactericidal, and fluoride. Of these, the abrasive is the most important. The most common pumices are hydrated silica (H₂SiO₃). The antibacterials are usually some form of sodium, and the fluorides can be either stannous or sodium.
fluoride. The pumice physically disrupts the biofilm’s mucopolysaccharide covering, increasing both the bactericide’s and fluoride’s effectiveness. The patient should expect a little tingling as these elements are carried down the root into the sulcus, and there may be some bleeding in the most inflamed areas due to ulcerations in the lining of the sulcus. Both the tingling sensation and bleeding resolve quickly. The patient should expect an overall decrease in bleeding after 2 to 3 weeks of

this daily treatment.\textsuperscript{17} Areas of bulky or bulbous tissue should shrink as well. If some of the more difficult areas continue to bleed, the patient should spend more time on these isolated areas at each cleaning, and usually these areas will cease to bleed. Breath odor issues should also improve. In periodontal pockets greater than 4 mm, you may not touch bottom with the floss, and these pockets may require professional help. Scaling and root planing in the dental office is still the standard of initial care.\textsuperscript{18}

Be aware that many toothpastes are so heavily laden with flavorings and astringents that when first contact is made with the tongue and taste buds, the mouth may feel clean before any removal of bacteria from the teeth. Key techniques for patients to effectively remove bacteria using the Paste, Wrap, and Shimmy method can be found in the table.

**Conclusion**

In 5 years of teaching this technique, the author and his staff have had some very satisfying results. The staff schedules an extra 15 minutes at every new patient’s first appointment to teach the regimen, and additional hygiene time is allotted at every recall appointment to reinforce it. The techniques are demonstrated in the patient’s mouth, and the staff uses intraoral images and presentations for reinforcement. Approximately 20\% of the people accept it and use the technique after their first exposure to the regimen. Another 20\% never master it due to lack of interest. For the 60\% who make some attempt at brushing and flossing in this manner, we see very steady improvement. In teaching events around the country, the author finds that many dentists practice this technique themselves in some form—but don’t believe their patients will put forth the effort to master it. However, when first introduced to it, almost every patient asks, “Why hasn’t anyone shown me this before?”

It is a fair question, and it deserves an answer. In 1972, Dr. Robert Barkley wrote a popular book of the period, *Successful Preventive Dental Practices*.\textsuperscript{19} He did not have intraoral cameras or PowerPoint presentations to help him teach his patients, nor did he have a complete understanding of biofilms. But he did have a passion to educate his patients to become independently healthy. He proclaimed a need for the dental team to become educators, or watch the profession “dilute...toward mediocrity.” Our patients deserve this self-help and health-centered dental approach. To paraphrase a popular marketing theme, “Paste, Wrap, and Shimmy...you can do it; we can help.”
Since 1980, Dr. Jester has taught AGD-certified continuing education programs for the United States Dental Institute. He maintains a broad spectrum preventive dental practice in West Chester, Pennsylvania.

Disclaimer
The author has no financial, economic, commercial, and/or professional interests related to topics presented in this article.

References
Assessment of the release of mercury from silver amalgam alloys exposed to different 10% carbamide peroxide bleaching agents

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This in vitro study assessed the amount of mercury (Hg) released from a silver amalgam alloy following the application of different 10% carbamide peroxide bleaching agents. A total of 30 specimens (2 mm thick x 4 mm in diameter) were stored in deionized water at 37°C for 7 days. Next, the control group (n = 10) remained in the deionized water for 15 days, while the remaining samples were exposed to one of 2 bleaching agents (n = 10) for 8 hours daily (total exposure = 120 hours); for the remaining 16 hours, specimens in the test groups were stored in deionized water at 37°C under relative humidity. After this period, the quantity of Hg in the deionized water was assessed (using atomic absorption spectrophotometry) and compared to the amount of Hg at baseline. The results indicate that exposing amalgam alloys to bleaching agents released greater amounts of Hg compared to exposing samples to ionized water.

Materials and methods
A silver amalgam alloy with a high copper content (Permite-C, SDI (North America) Inc.), was used to fabricate 30 specimens (2 mm thick x 4 mm diameter). All specimens were immersed in deionized water at 37°C for 7 days. Specimens were divided into 3 groups for the 15-day test period. Specimens in Group 1 (control group) (n = 10) remained in deionized water, while specimens in Groups 2 and 3 (n = 10) were exposed for 8 hours daily (following the manufacturer’s recommendations) to one of two 10% carbamide peroxide bleaching gels (Table 1). Group 2 was exposed to Opalescence PF (Ultradent Products, Inc.), which contains 10% carbamide peroxide, 0.5% potassium nitrate and 0.11% (1,100 ppm) fluoride ion. Group 3 was exposed to a generic 10% carbamide peroxide compound (Dermapelle Handling Pharmacy). For the other 16 hours each day, samples in Groups 2 and 3 were kept in deionized water at 37°C under relative humidity. After 15 days, ions released in the deionized water were assessed using atomic absorption spectrophotometry. The nominal amounts of Hg released were tabulated in spreadsheets and analyzed using a descriptive statistical program (SPSS version 18.0, IBM Corporation). Normality of distribution was verified by the Shapiro-Wilk test, and homoscedasticity was verified by the Levene test. The values for Hg released underwent base-10 log transformation to perform the parametric tests; at that point, ANOVA and Tukey post hoc tests (P < 0.05) were used to compare data in Groups 1-3.

Table 1. Composition of bleaching agents used.

<table>
<thead>
<tr>
<th>Bleaching agent</th>
<th>Composition</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opalescence PF</td>
<td>10% carbamide peroxide, 0.5% potassium nitrate, 0.11% (1,100 ppm) fluoride ion</td>
<td>Ultradent Products, Inc.</td>
</tr>
<tr>
<td>10% carbamide peroxide compound</td>
<td>10% carbamide peroxide, stabilizers, and thickeners</td>
<td>Dermapelle Handling Pharmacy</td>
</tr>
</tbody>
</table>
Table 2 shows the mean values and SDs obtained after performing the statistical analysis. There is a statistically significant difference between the release of Hg in Groups 2 and 3 and the amount released by the control group (Group 1).

Statistics $d$ and $r$ were used to calculate the effect sizes for each of the three groups. Effect sizes complement other, more inferential statistics, such as $P$ values. A great effect is the same as a statistically significant difference between groups. A medium effect means that although there is a difference, it is not statistically significant. Statistics for Group 3 resulted in $d = -1.28$ and $r = 0.54$, which is considered a great effect; while statistics for Group 2 resulted in $d = 0.37$ and $r = 0.18$, considered a medium effect. Although Group 3 specimens produced higher mean values of Hg compared to Group 2 specimens, this difference was not considered statistically significant. Differences were considered to be statistically significant only when specimens in Groups 2 or 3 were compared with those in Group 1. The chart shows the amount of Hg released by each group.

#### Discussion
Silver amalgam is a restorative material consisting primarily of Hg, silver, copper, and tin. This material is not technically considered to be sensitive; however, it undergoes a continuous corrosion process, which gives it a self-sealing quality.

In the experimental design used in the present study, the use of silver amalgam alloy capsules with a high copper content enabled the standardization of the quantity of Hg present in each test specimen. The alloy's high copper content offered improved mechanical and physical properties, including a reduction in the formation of the gamma 2 phase, reduced corrosion, and increased strength. For the present study, 10% carbamide peroxide was chosen as the test material, as this concentration is used most frequently in supervised home bleaching techniques and mentioned most frequently in studies that assess the effect of bleaching agents on restorative materials.

Exposure to metal ions (especially Hg) is a potential danger to health and could cause serious toxic effects, damaging the brain, kidneys, and lungs and leading to such conditions as acrodynia, Minamata disease, and Hunter-Russell syndrome. According to the World Health Organization, the maximum recommended intake of Hg is 40 mg/kg of body weight per day, while the provisional tolerable weekly intake (PTWI) limit is estimated to be 300 μg of total Hg and 200 μg of methylmercury, which corresponds to 5 μg/kg of total Hg or 3.3 μg/kg of methylmercury for a person weighing 60 kg. In turn, these values produce an acceptable daily intake (ADI) of 0.5 μg/kg of methylmercury and 0.7 μg/kg of total Hg. The literature has reported adverse effects on the central nervous system of adults following a daily Hg intake of 3-7 μg/kg, resulting in levels of Hg in the blood ranging from 200 to 500 μg/L. Exposure to Hg can also occur from breathing contaminated air, using and/or improperly disposing of fluorescent lamps, coal combustion in power plants, and intake of food containing residues of Hg. In addition, silver amalgam restorations might release Hg after dental bleaching.

Previous studies have assessed how exposure to bleaching agents affects surface changes in silver amalgam restorations. In a 2004 study, Schemehorn et al applied a 6% concentration of a hydrogen peroxide bleaching agent to silver amalgam for 20 minutes a day for 28 consecutive days; scanning electronic microscopy (SEM) performed at the end of this period found no surface changes. Similarly, Duschner et al applied peroxides for 70 hours but found no surface changes or altered microhardness. However, a 2003 study by Campos et al exposed silver amalgam to 10% and 15% carbamide peroxide bleaching agents (6 hours a day for 21 days) and reported a loss of microhardness.
More recently, a 2007 in vitro study by Al-Salehi et al analyzed the release of Hg ions from silver amalgam after treating specimens with hydrogen peroxide at concentrations of 1%, 3%, 10%, and 30%. In the first 24 hours of treatment, the authors collected samples to determine the release of metal ions and measured surface roughness before and after bleaching. As in the present study, metal alloy corrosion was higher and Hg release increased as concentrations of hydrogen peroxide increased.

The release of metal ions and Hg from amalgam restorations varies, depending on the time and in proportion to the size of the restoration surface. The amount of Hg released daily from an amalgam restoration can vary. Rotstein et al assessed amalgam samples bleached with 10% carbamide peroxide 48 hours after the completion of bleaching treatment and found concentrations of Hg ranging from 0.6 to 4.24 μg/mm². Mackert & Berglund reviewed 6 different in vivo studies and found that the amount of Hg released from dental amalgam restorations ranged from 0.014 to 0.016 μg/mm².

A similar study by Hummert et al found that exposing amalgam restorations to dental bleaching released 0.014-0.020 μg/mm² of Hg, compared to 0.001 μg/mm² when amalgam was exposed to a saline solution. These results are in keeping with the values found in the present study, where the amount of Hg released increased significantly (P < 0.05) when amalgam was exposed to 10% carbamide peroxide. The mean values for the three groups are listed in Table 2.

Based on the literature and the present study, solutions of 10% carbamide peroxide increase the amount of Hg released from silver amalgam. Because Hg is released naturally in the oral cavity when saliva is present, frequent and prolonged exposure to bleaching agents might increase the risk of poisoning by Hg exposure while also causing changes in physical, mechanical, and structural properties of restorations, thus reducing their longevity. When performing bleaching treatments on patients with silver amalgam restorations, dentists must avoid unnecessarily exposing these restorations to 10% carbamide peroxide bleaching agents. It is recommended that bleaching treatments are performed by the dentist in the office or that silver amalgam restorations are replaced before patients perform any at-home bleaching treatments.

**Conclusion**

Silver amalgam specimens treated with 10% carbamide peroxide bleaching agents produced a statistically significant increase in the quantity of Hg released after 15 days compared with the control group. Additional studies are needed to assess the impact of this increase. However, the authors recommend avoiding the indiscriminate exposure of silver amalgam restorations to carbamide peroxide bleaching agents.

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www.agd.org General Dentistry January/February 2013 35
Overview of CEREC CAD/CAM chairside system

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Dalia A. Madani, DDS, MSc, BSc • Omar El-Mowafy, BDS, PhD

This article describes CAD/CAM technology used in dentistry and different restorative materials used in conjunction with adhesive cementation with particular attention given to the evolution of the CEREC system, as well as various ceramics developed for this system. Advantages and limitations of materials and technique are also discussed.

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The demand for esthetic restorations has increased dramatically over the past two decades. The search for new methods has been driven in part by patients who have increasingly high expectations in esthetic dentistry and concerns about the intraoral biocompatibility of metals.1 While metal-ceramic systems are a high-strength mode of treatment with positive long-term success rates, they also are associated with certain disadvantages, including esthetic concerns and the potential for allergic reactions (gold allergies are rare, but have been documented in the literature).2 Several studies have investigated the prevalence of metal contact allergy among various populations.3-7 Metal contact allergy was reported to be 0.8%-9.5% for gold, 1.6% for silver, 9% for cobalt, 8.2% for tin, 8% for palladium, 8% for chromium, and 14.3%-29% for nickel.3-7

Ceramics have become a popular restorative material due to their high esthetic quality, wear resistance, durability, color stability, and biocompatibility.8-12 Disadvantages of ceramics include the high cost of fabrication, low fracture resistance, difficulty in repairing, excessive wear of opposing teeth, the need for a more aggressive preparation design, technique sensitivity, and less-than-ideal marginal adaptation.13-16

Advancements in dental materials, computer technology, and equipment have made it possible to fabricate an indirect esthetic restoration in one appointment while the patient is waiting. The computer-aided design/computer-aided manufacture (CAD/CAM) CEREC (computer-assisted CERAmic REConstruction) system is used for electronically designing and milling restorations. Using this system, the dentist can manufacture a restoration without the need for laboratory assistance, impressions, or temporary restorations.17 The restoration can be designed in less than five minutes and milled in 10-12 minutes, resulting in significant time savings for both the patient and dental practice.18 The CEREC system (Sirona Dental Systems, Inc.) was the first operational CAD/CAM system to be used in the dental offices.19 The first chairside inlay was fabricated with the CEREC 1 in 1985.20 In 1988, onlay and veneer capabilities were added to the unit. Full and partial crowns and copings were made possible in 1994 with the introduction of the CEREC 2. In 2000, the CEREC 3 (Sirona Dental Systems, Inc.) was introduced; by 2003, the CEREC units had 3-dimensional capability. New software was added in 2005 that enabled automatic virtual occlusal adjustment.20

Several studies criticized the marginal fit of CEREC restorations.21-22 However, with the latest improvements in the CEREC unit and software, it is possible to produce a more clinically acceptable marginal fit of the milled restorations.23-24

The design and manufacturing process involves optically scanning and digitizing dies created from the master impression of the prepared teeth/cores, so that the dimensions of the margins may be duplicated precisely. The scanned 3-dimensional images of the dies are then used to design the substructure, prompted by computer software. The CAD unit is linked to a robotic CAM center that creates a restoration according to the design specifications.1

Advantages of the CEREC technology

The clinical success and longevity of CEREC restorations have been documented in the literature.25 Restoration size, tooth vitality, and tooth location do not significantly affect the prognosis. A 2003 study by Posselt & Kerschbaum reported a survival probability of 95.5% over nine years.25

The CAD/CAM ceramic blocks are fabricated under optimum conditions, creating a restoration with higher intrinsic strength without the variation in materials found in laboratory-fabricated restorations.26 The computer-controlled fabrication diminishes the potential for inaccuracies due to human error and makes it possible to generate a restoration within a clinically acceptable fit of 50 μm, as established by the American Dental Association.27

Because only one appointment is needed to complete the restoration, the patient is subjected to only one administration of local anesthetic. In addition, there is no need to fabricate a temporary restoration which is at risk of loss, breakage, or leakage and may produce sensitivity and/or contaminate the dentinal tubules.28 Temporary restorations may be hard to clean and maintain during the temporization period, which can lead to gingival irritation; in addition, pulpal stress may occur when the temporary restoration is removed, due to excessive cleaning, drying, or trauma.29

By manufacturing and completing the restoration in a single appointment, the office can improve efficiency by decreasing second-chair setup costs, reducing the number of instruments that require sterilization, and eliminating the cost of disposable supplies required for conventional restorations (including impression materials, wax, stone, temporary resin material, and temporary cement).25 In addition, the clinician has complete control over the final result and esthetics of the restoration since the software delivers a restoration that should require only staining or glazing.29 A well-trained, dedicated staff is mandatory for a successful restoration. However, staff
members can make the restoration after the dentist has prepared the tooth. This saves time, which adds to the financial viability of the CEREC technology.

CEREC restorations are associated with minimal reported postoperative sensitivity, due to rubber dam isolation in the clinical trials that ensures a clean, isolated tooth surface for adhesion bonding.\(^{30}\) Inserting the restoration at the same appointment as the preparation prevents possible tooth contamination during the temporization phase; in addition, using factory-manufactured composite and ceramic blocks minimizes the polymerization shrinkage by limiting it to the resin-cement interface.\(^{30}\) Finally, no laboratory fee is involved with CAD/CAM restorations.

**Limitations of CEREC technology**

One factor that could limit the use of CEREC technology is the cost of the equipment, especially for dentists in solo practices. In addition, the color of the finished restoration may not be ideal since the restoration is milled from a monochromatic block. However, multicolor blocks have been developed to overcome this limitation; in addition, dentists can place superficial stains to mimic any shade variability in the patient’s teeth.

It takes significant time for a dentist to become proficient enough in the use of this system to achieve financial success.\(^{29}\) A 2007 study reported that dental students introduced to CEREC 3 in their last semester were able to produce clinically acceptable inlays with a high short-term (2 years) success rate.\(^{31}\)

It is difficult to digitally capture subgingival-placed margins for severely broken teeth; in such cases, gingival retraction is needed. CAD/CAM technology in the dental office is limited to single units only, and a CEREC restoration takes longer to polish compared with a laboratory-manufactured restoration. However, with experience, the dentist may become faster and more efficient in performing these tasks.\(^{28}\)

**Concerns of the CEREC materials**

**Strength**

The blocks used with the CEREC equipment are fabricated under ideal manufacturing conditions in a reproducible manner that eliminates human error, which results in a dense, defect-free, high-quality material. Conventionally fabricated restorations are made by hand, which may lead to human error that could affect the restoration’s mechanical and esthetic properties.\(^{32}\) A 2000 study by Tinschert et al concluded that industrially prepared ceramics are more structurally reliable than conventional laboratory-fabricated ceramics, although CAD/CAM milling procedures may induce surface and subsurface flaws that may adversely affect the strength of this ceramic.\(^{33}\) However, the strength can be restored by polishing the material with rubber wheels and diamond paste. Further enhancement of strength (to approximately 160 MPa) can be acquired by a combination of polishing and glazing.\(^{33}\) In a 2004 study, Artia and Kern concluded that the fracture resistance of teeth restored with CEREC-manufactured crowns was equal to that of unprepared natural teeth, but was significantly higher than that in teeth restored with conventional low-fusing ceramic crowns.\(^{16}\)

**Esthetics**

As noted earlier, the esthetics of CEREC materials are a concern due to the monochromatic nature of the blocks. However, a porcelain restoration can be stained and glazed after milling; in addition, the blocks are available in a variety of shades to match the adjacent natural dentition. A clinical study by Herguth et al compared the esthetics of CEREC-manufactured crowns to crowns fabricated using the layering technique, and concluded that both restorations were esthetically acceptable to all patients with no statistically significant difference in the esthetic ratings between the two crowns.\(^{34}\)

A series of studies evaluated 66 ceramic inlays (Vitablocs Mark II, Vident) and reported that the color mismatch increased after 10 years from 16% to 38%.\(^{35-37}\) According to Fasbinder et al, the increased color mismatch was due to the tooth changing color rather than a color shift in the milled restoration.\(^{30}\) More recently, Fasbinder et al reported a significantly better color match for CEREC-manufactured composite inlays (Paradigm, 3M ESPE) compared with Vitablocs Mark II ceramic inlays at 3 years, as the composite resin appeared to reflect the surrounding tooth color to a better degree than the ceramic inlays.\(^{39}\)

CEREC-manufactured restorations can provide an esthetically acceptable restoration when polished, and an esthetically optimum one when stained and glazed. The decreased color match over time can be attributed to a change in tooth shade and translucency, rather than a change in the color of the CEREC-manufactured restoration.\(^{40}\)

**Postoperative sensitivity**

Early clinical studies reported significant levels of postoperative sensitivity among CEREC restorations. In a study of 301 inlays, Magnuson et al reported that 9% experienced immediate post-operative sensitivity.\(^{41}\) Most cases involving postoperative sensitivity resolved within 1 month.\(^{42}\) A 3-year clinical study by Fasbinder et al reported that 13% of 92 Vitablocs Mark II onlays were slightly sensitive after 1 week, and 4% of the 92 onlays were slightly sensitive after 2 weeks.\(^{42}\) All postoperative sensitivity was resolved after 1 month, and no other postoperative sensitivity was reported during the 3-year period of observation. Most cases of postoperative sensitivity can be attributed to occlusal interference, since the restorations are inserted in a single appointment. Fasbinder advised equilibrating the occlusal contacts after the effects of the local anesthetic have dissipated.\(^{40}\)

More recent studies have reported less postoperative sensitivity, which could be attributed to the significant improvement of the adhesive materials. Molin & Karlsson examined 20 CEREC-generated Vitablocks Mark I inlays (Vident) over five years and reported no postoperative sensitivity throughout the observation period.\(^{43}\)

The absence of significant postoperative sensitivity in such restorations can be attributed to several factors. First, the optical imaging of the preparation requires careful isolation, which ensures optimum fluid control and which maximizes the predictability of cementation.\(^{40}\) The fact that CEREC-manufactured restorations eliminate the need for temporization contributes to the lack of postoperative sensitivity, preventing contamination of the dentin tubules during the temporization period that can occur with a lost, fractured, or leaking temporary restoration.\(^{39}\)
Margin adaptation
In 2003, Nakamura et al studied how abutment occlusal conversion angle and the computer luting space setting affected the internal fit and marginal adaptation of the ceramic CEREC 3-milled restoration. The authors found that setting the computer luting space at 30-50 μm produced a marginal gap of 53-67 μm that was not influenced by the abutment angle of occlusal conversion. Other researchers measured margins of approximately 50 μm, suggesting that the marginal fit of CAD/CAM-generated restorations is adequate for clinical use. Denissen et al reported a margin gap of 85 μm for CEREC 3-manufactured onlays, a gap that was not significantly different from laboratory-fabricated onlays. These recorded gaps are well within the reported maximum clinically accepted gap of 120 μm.

A well-fitting margin is expected to maximize the longevity of a restoration. Almost all clinical studies of CEREC-manufactured restorations reported ditching due to wear of the composite resin cement at the margin. However, this ditching was not associated with margin discoloration or recurrent decay. A 1992 clinical study of CEREC-manufactured inlays cemented with microfilled or hybrid resin-based composite luting agent reported a linear wear rate in the first year that decreased after 3 years by approximately 50%. The authors reported that the vertical loss of cement at the margin stopped when it reached 50% of the margin width and that no microleakage or secondary decay was reported at the margin. More recently, Heymann et al reported that the wear of the adhesive luting agent at the occlusal margin of inlays increased over the first 3 years, and decreased over the next 3 years. No margin chipping or staining was identified in the enamel or porcelain inlays as the adhesive cement started to wear. In an in vitro comparative study with hot-press technique and CEREC-manufactured restorations, Keshvad et al reported that leucite-reinforced glass-ceramic inlay restorations fabricated using CAD/CAM technology and the hot-pressed technique provided clinically acceptable marginal and internal fit with comparable fracture loads after luting.

Enamel wear
Enamel wear is always a concern when ceramics are used as a restorative material. Several factors may influence how ceramics affect enamel tooth structure. It is possible to minimize enamel wear by using fine-grained ceramics and polishing or glazing the ceramic surface. Several studies have demonstrated that the wear of enamel against polished or glazed ceramic restorations was essentially the same as that for enamel against porcelain.

Longevity
Several studies have examined the success and longevity of CEREC-manufactured restorations. In the first such clinical trial, Mormann et al evaluated 94 Vitablocs Mark I inlays between September 1985 and August 1987 and reported only 2 fractured inlays during that time. In 2002, Otto & De Nisco studied 200 Vitabloc Mark II inlays over 10 years of clinical service and reported a 90.4% survival rate. In 8 cases, failure was caused by ceramic fracture; in 3 cases, by tooth fracture. In a 2004 in vivo study, Bindl & Mormann compared 18 anterior Vitablocs Mark II crowns to 18 anterior ceramic core crowns over 2 to 5 years. The ceramic core crown survival rate was 91.7%, compared to 94.4% for Vitablocs Mark II, without a statistically significant difference.

A 2003 study by Posselt & Kerschbaum evaluated 2,328 ceramic inlays and onlays in 794 patients and reported a survival rate of 95.5% at 9 years. The majority of failures were caused by inlay fracture, tooth fracture, tooth extraction, and replacement for occlusal reconstruction. A series of articles evaluated 1,011 inlays and onlays placed in 299 patients between 1987 and 1990 for up to 18 years. The authors determined a survival probability of 95% after 5 years, 91.6% after 7 years, and 90.0% at 10 years; a survival rate comparable to conventional ceramic restorations.

The low failure rate of CEREC-manufactured restorations documents the reliability and the clinical predictability of such restorations.

Ceramics used for chairside CEREC
Feldspathic porcelain-based ceramic
Vitablocs Mark II is a fine-grained feldspathic ceramic that produces fine crystal (average size = \(4 \mu m\)). The pore-free ceramic is easier to polish and demonstrates low enamel wear and high strength. According to the manufacturer, the feldspar particles are uniformly embedded in the glass matrix, avoiding a detrimental “sanding (abrad ing) effect” on the antagonist. When polished, the strength of this ceramic material is approximately 130 MPa and it could reach 160 MPa or higher if glazed. This strength is approximately twice that of conventional feldspathic ceramics and also is higher than several pressable ceramics.

Empress CAD blocks
IPS Empress CAD (Ivoclar Vivadent) is a leucite-glass-ceramic of the SiO₂-Al₂O₃-K₂O materials system with leucite crystals ranging from 5 to 10 μm in size. The leucite (KAlSi₂O₆) crystals increase the material’s strength and slow down or deflect crack propagation, while the crystalline phase absorbs fracture energy. According to Giordano, this leucite-reinforced ceramic material has properties of strength and surface characterization similar to those found in Vitablocs Mark II.

IPS e.max CAD blocks
IPS e.max CAD (Ivoclar Vivadent) is a lithium disilicate glass-ceramic for CAD/CAM applications. The blocks are produced by massive casting of transparent glass ingots. A continuous manufacturing process based on glass technology (that is, pressure-casting) is utilized to prevent the formation of defects (pores, accumulation of pigments, and so forth) in the bulk of the ingot. Partial crystallization ensures that the blocks can be processed in a crystalline intermediate phase, which enables fast machining with CAD/CAM systems. The partial crystallization process leads to a formation of lithium metasilicate (Li₂SiO₃) crystals, which are responsible for the material’s optimal processing properties, edge stability, and relatively high strength.

After the milling procedure, the restorations are tempered and lithium disilicate (Li₂SiO₃) crystals are formed, which impart the ceramic object with the desired high strength. A 2010 study by Guess et al tested monolithic CAD/CAM lithium disilicate and hand-layer-veneered zirconia all-ceramic crowns and found that using IPS e.max CAD
Paradigm MZ100
Paradigm MZ100 (3M ESPE) is a bispheno-A-diglycidyl methacrylate/triethylene glycol dimethacrylate resin-based composite with filler composed of nanocrystalline zirconia in an amorphous silica matrix. Paradigm MZ100 block material contains 85% ultrafine zirconia-silica ceramic particles by weight, which reinforce a highly crosslinked polymeric matrix (with a mean particle size of 0.6 μm). It has superior physical properties compared to conventional resin due to controlled manufacturing conditions, which leads to a dense and pore-free material that is completely infiltration resistant due to controlled manufacture. Physical properties compared to conventional ceramic crowns resulted in fatigue-resistant crowns, while microleakage scores compared to ceramic crowns.

More recently, the same authors conducted an in vitro study by Kassem et al found that crowns made with Paradigm MZ100 were highly resistant to failure from mechanical fatigue and produced significantly higher mean microleakage scores compared to ceramic crowns.

Paradigm MZ100 is a more triple-cured or chemically cured resin composite luting agent. The authors have no financial, economic, commercial, and or/and professional interests related to topics presented in this article.

Summary
In this review, the authors presented current evidence suggesting that CEREC-manufactured restorations have an acceptable marginal adaptation and clinical longevity along with reduced chair time and improved esthetics. Evidence from many clinical studies suggests that clinicians may choose this system on the basis of patients’ aesthetic needs. The evidence provided here should enable clinicians to enter into informed consent decisions with their patients who desire all-ceramic restorations.

Author information
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References
Information Technology/Computers Overview of CEREC CAD/CAM chairside system


Manufacturers

Ivoclar Vivadent Inc., Amherst, NY
800.533.6825, www.ivoclarvivadent.us

Siemens, Washington, DC
800.743.6367, www.usa.siemens.com

Sirona Dental Systems, Inc., Long Island City, NY
718.937.5765, www.sirona.com

Vident, Brea, CA
800.828.3839, www.vident.com

3M ESPE, St. Paul, MN
888.364.3577, solutions.3m.com
The 15 questions for this exercise are based on the article *Overview of CEREC CAD/CAM chairside system*, on pages 36-40. This exercise was developed by Daniel S. Geare, DMD, in association with the General Dentistry Self-Instruction committee.

Reading the article and successfully completing this exercise will enable you to understand:
- the advantages and limits of CEREC technology;
- the clinical qualities of CAD/CAM restorations; and
- the types of porcelain and composite used in CAD/CAM technology.

1. The disadvantages of metal-ceramic restorations include all of the following except one. Which is the exception?
   - A. Metal allergy
   - B. Esthetics
   - C. Corrosion
   - D. Low shear strength

2. Prevalence for contact allergy in nickel-containing crowns is reported to be as high as _____%.
   - A. 0.88
   - B. 8
   - C. 9
   - D. 29

3. Popular characteristics of ceramic crowns include all of the following except one. Which is the exception?
   - A. Greater esthetics
   - B. Increased durability
   - C. Reduced pulpal trauma
   - D. Greater wear resistance

4. The maximum clinically acceptable margin gap for all crowns is _____ μm.
   - A. 65
   - B. 80
   - C. 120
   - D. 135

5. The CAD/CAM CEREC system eliminates the need for all of the following except one. Which is the exception?
   - A. Impressions
   - B. Provisionalization
   - C. Lab assistance
   - D. Preparation design

6. Criticism of the CEREC system was focused on
   - A. marginal fit.
   - B. color stability.
   - C. occlusal design.
   - D. fracture resistance.

7. The CEREC crowns have been shown to have better esthetics than standard porcelain crowns. There is a reduction in color matching due to the change in tooth shade over time.
   - A. Both statements are true.
   - B. The first statement is true; the second is false.
   - C. The first statement is false; the second is true.
   - D. Both statements are false.

8. The CAD/CAM restorations have a marginal fit of approximately _____ μm.
   - A. 15
   - B. 25
   - C. 50
   - D. 90

9. Limits of the CAD/CAM system include all of the following except one. Which is the exception?
   - A. Need to use gingival retraction
   - B. Single units only
   - C. Polishing time
   - D. Unpredictable shades

10. CAD/CAM-prepared restorations are more structurally reliable than laboratory-made restorations. This is because CAD/CAM restorations eliminate subsurface flaws in the ceramic.
    - A. Both statements are true.
    - B. The first statement is true; the second is false.
    - C. The first statement is false; the second is true.
    - D. Both statements are false.

11. According to Attia & Kern, fracture resistance of teeth restored with CEREC-manufactured crowns was _____ unprepared natural teeth.
    - A. equivalent to
    - B. less than
    - C. more than
    - D. unrelated to

12. Postoperative sensitivity with CEREC restorations is primarily attributed to
    - A. occlusal interference.
    - B. marginal leakage.
    - C. excessive preparation depth.
    - D. poor tooth isolation on cementation.

13. Failure of ceramic inlays and onlays is caused by all of the following except one. Which is the exception?
    - A. Poor preparation design
    - B. Tooth fracture
    - C. Tooth extraction
    - D. Inlay fracture

14. All of the following statements are true except one. Which is the exception?
    - A. Feldspathic porcelain uses leucite particles embedded in a glass matrix.
    - B. Empress porcelain resists cracks due to leucite crystals.
    - C. IPS e.max porcelain resists fracture by high-pressure fusing of porcelain powder.
    - D. Paradigm MZ100 crosslinks zirconia with a silica matrix.

15. Disadvantages of CAD/CAM include all of the following except one. Which is the exception?
    - A. Time for training
    - B. Cost of equipment
    - C. Time to polish restorations
    - D. Capturing the digital impressions

Answer form is on page 80. Answers for this exercise must be received by December 31, 2013.
Clinical long-term evaluation of acellular dermal matrix in the treatment of root recession: case report

Joao Carnio, DDS, MS • Marcel Fuganti, DDS

Several clinical studies have documented success when using an acellular dermal matrix (ADM) to treat mucogingival defects; however, information concerning its long-term stability is limited. This article presents a case involving a patient with root recession treated with an ADM. Probing depth, marginal tissue recession, and the amount of keratinized and attached tissues were evaluated for 10 years post-treatment; the results showed long-term stability during the observation period.

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One of the key goals of periodontal surgery is obtaining predictable and esthetic root coverage, while increasing the area of attached gingiva. Various surgical techniques that have been employed to achieve this goal include pedicle flaps, epithelialized free palatal grafts, subepithelial connective tissue grafts (CTGs), and guided tissue regeneration. Among these, the subepithelial CTG is considered the gold standard technique for root coverage procedures.

However, this graft requires autogenous palatal donor tissue, which causes an additional surgical palatal wound that could increase the risk of complications, and it is directly related to greater postoperative discomfort to the patient.

The literature has reported on the success of an acellular dermal matrix (ADM) for periodontal purposes. This material is an allograft, obtained from an aseptic process in which skin cells are removed, eliminating the source of infection, disease transmission, and immunological reaction. ADM has been used extensively to replace autogenous donor tissues in cases of primary and secondary burn reconstruction. Its structure serves as an architectural support for fibroblast migration and revascularization to periodontal tissues, reducing operative time, avoiding possible palatal complications, and improving the patient’s postoperative recovery. According to Harris, these advantages have increased acceptance among both patients and periodontists.

According to the literature, the use of Alloderm (LifeCell Corporation) provides predictable root coverage, with mean root coverage ranging from 86% to 95.8%; however, this information about Alloderm was obtained from studies and cases with short follow-up periods (≤6 months).

This case report sought to evaluate the long-term stability of a root coverage procedure that utilized an ADM. The preoperative and postoperative amount of root coverage and the increase in keratinized and attached tissues were compared.

Materials and methods

A 36-year-old nonsmoking woman in good general health had a chief complaint of root hypersensitivity to cold. Clinical examination showed the presence of incipient marginal tissue recession in the region of teeth No. 28 and 29, as well as a minimal apico-coronal dimension of keratinized tissue, and abrasion of the cervical root region due to traumatic toothbrushing (Fig. 1 and 2, Table). The patient agreed to receive the ADM for a palatal wound that caused great postoperative discomfort.

Professional plaque control was performed prior to the surgical procedure and the patient was instructed in proper oral hygiene habits. Presurgical measurements included probing depth, marginal tissue recession, and the amount of keratinized and attached tissues were evaluated for 10 years post-treatment; the results showed long-term stability during the observation period.

Fig. 1. Teeth No. 28 and 29, showing an incipient Class I recession.

Fig. 2. Teeth No. 28 and 29 following application of Schiller’s solution. Note the presence of a moderate amount of keratinized tissue.
instructions (LifeCell Corporation). The graft was placed so that it extended approximately 3 mm over the surrounding bone. The material was oriented so that the white basement membrane side (Fig. 5) was placed adjacent to the bone and tooth, and the red connective tissue side (Fig. 6) was placed toward the flap. The orientation used was opposite from what the manufacturer suggested for a free gingival graft; however, this orientation is normally utilized when the ADM is subepithelialized.

The graft was stabilized in the cemento-enamel junction using No. 6-0 absorbable suspensory sutures (Fig. 7) and the flap was positioned coronally using No. 4-0 silk interrupted single sutures. Approximately 1 mm of the ADM was intentionally exposed to the oral environment (Fig. 8). Postoperative recommendations included 500 mg of amoxicillin (taken 3 times daily for 7 days), 600 mg of ibuprofen (twice daily for 4 days, as needed), and 0.12% chlorhexidine mouthwash (twice daily for 4 weeks, beginning after the second week of healing). The patient was instructed to refrain from mechanical oral hygiene practices for 6 weeks after surgery (professional tooth cleaning was performed every week during that period), when the patient could resume home brushing and flossing.

Results
Healing occurred uneventfully during the first 12 weeks of observation (Fig. 9-12). Probing depth remained unchanged, marginal tissue recession was eliminated and stability was maintained throughout the observation period. Keratinized tissue and attached gingiva demonstrated a slight increase in the corono-apical direction (with variations of approximately 1 mm), but remained stable over the 3-month healing period and throughout the 10-year observation period (Table).

Clinically, the connective tissue thickness increased significantly, although it was not measured initially (Fig. 13-15). The exposed area of the ADM remained clinically visible for 2 weeks postsurgery, and was integrated into the tissues completely after 4 weeks (Fig. 8). It is important to note that the patient did not return for periodontal support.

<table>
<thead>
<tr>
<th>Time point</th>
<th>Tooth 28</th>
<th>Tooth 29</th>
<th>Tooth 28</th>
<th>Tooth 29</th>
<th>Tooth 28</th>
<th>Tooth 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pocket depth</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Keratinized tissue</td>
<td>1.0</td>
<td>2.0</td>
<td>2.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Attached gingiva</td>
<td>0.0</td>
<td>1.0</td>
<td>1.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Gingival recession</td>
<td>2.0</td>
<td>1.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
therapy after the initial 12-week maintenance care program; however, the surgical site always showed a high level of plaque control during recall visits.

Discussion
ADM was developed as a dermal replacement for burn patients. It is an allograft, derived from human skin, in which the epidermis and all of the cells of the dermis have been removed through a freeze-drying process, which prevents specific inflammatory reactions due to the graft. ADM is a biomaterial containing components of types IV and VII collagen, elastin, and laminin, and can be inserted without the risk of rejection from the host’s immune system.

Histologically, ADM resembles normal dermis, without the skin’s cellular and vascular components. Compared to human gingival tissue, ADM has an abundance of elastin, which is present in the oral mucosa, but not in the gingival tissue. ADM acts as a scaffold (matrix) for the formation of normal tissue architecture and also as a mold for tissue regeneration. When an ADM is transplanted, it creates a space that is occupied by other host cells. Fibroblasts and capillaries invade these spaces and tend to proliferate into the new tissue. New collagen fibers replace the existing graft fibers, which are reabsorbed gradually.

Although histological studies concerning the incorporation of ADMs are limited, animal and human studies have reported the graft integrating with the tissues in a single highly vascularized structure (without the presence of inflammatory cells) over a period of 10-12 weeks. The use of ADM in periodontal procedures is currently for root coverage. In comparative studies with subepithelial CTGs, ADM showed a minor increase of keratinized tissue. Because the graft tissue assumes the characteristics of the donor site, keratinization occurs through an induction mechanism. Although ADM derives from keratinized human skin, it is conceivable that the vitality of the graft may be essential to induce the keratinization of the overlaid flap. Unlike the subepithelial CTG, where the portion that remains exposed tends to differentiate itself, ADM must be covered completely to increase blood flow. Because an ADM is a non-vital allograft, its restructuring process depends on the proliferation of epithelial cells, blood vessels, and collagen fibers along its entire length. In turn, the CTG has some vessels and cells; as a result, healing and vascularization occurs through anastomoses between the recipient bed and the graft.

The process of increasing keratinized tissue with the use of an ADM is still unclear. Some authors suggest that this keratinization process will depend on the type and amount of cells that will colonize the graft. Since only the cells of the periodontal ligament and gingival tissue are capable of inducing the formation of keratinized epithelium, keratinization by the ADM depends on the quantity of these cells in the tissue. Thus, the type of tissue and the amount of keratinization on the flap covering the graft will determine the final amount of keratinization.

In the present case, the main purpose of the allograft was to provide root coverage; however, it also was expected to increase the amounts of keratinized tissue and attached gingiva. During...
the observation period, marginal tissue recession was eliminated and the probing depth remained unchanged. The amount of keratinized tissue and attached gingiva was considered to be satisfactory, as both increased slightly. The notion that the increase in keratinized tissue is due to the amount of ADM left exposed is questionable, since the graft must be, by indication, completely covered by the flap. It is in contrast to the use of subepithelial CTG, where in order to enhance the apico-coronal amount of keratinized tissue, one should leave a portion of the graft exposed to the oral environment. The final results are within acceptable limits since the literature has shown that approximately 2 mm of keratinized tissue with 1 mm of attached gingiva is enough to maintain a clinically healthy site. Clinical examination revealed an increase in the buccolingual dimension of the entire mucosal gingival complex on the buccal aspect of teeth No. 28 and 29. Although soft tissue thickness was not evaluated objectively in the present case, an increase was evident based on pretreatment and post-treatment evaluations. The data in this case report showed that an ADM was effective as a means of achieving root coverage, producing an increase in the apico-coronal dimension and thickness of keratinized tissue that remained stable for a period of 10 years.

Conclusion

Local results presented in the present case demonstrate that an ADM graft heals within expected parameters, completely integrates into the tissues within a period of 8 to 12 weeks, and remains stable for a long period of observation. The results indicate that ADM is a viable alternative for eliminating recession without needing palatal donor tissue. However, when interpreting the results, it should be noted that only one case was examined; as a result, whereas these data should be viewed as proof of the principle, additional research—utilizing a larger population—should be conducted to confirm the long-term stability of ADMS.

Author information

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References

This study sought to compare the marginal leakage and microhardness of low-shrinkage resin-based dental restorative materials containing ormocer- and silorane-based composites to that of conventional methacrylate-based systems. A total of 50 noncaries extracted human teeth were collected after debride ment and standard Class V cavities were prepared. Teeth were randomly assigned to five groups (n = 10) and restored with 5 types of resin-based restorative material composites: hybrid, microhybrid, nanohybrid, ormocer-based, and silorane-based. After thermocycling, all teeth were placed in a silver nitrate solution, sectioned longitudinally in a buccolingual direction, and observed under a stereomicroscope to determine the degree of dye penetration. Data were analyzed using a non-parametric Kruskal-Wallis test (P < 0.05). For the stereomicroscope to determine the degree of dye penetration. Data were analyzed by one-way ANOVA and Bonferroni post hoc tests. In terms of microhardness, there was no statistically significant difference among the resin-based restorative materials (P > 0.05). The degree of microleakage at the gingival margins was lowest for the silorane composite, followed by microhybrid and nanohybrid. The silorane composite was significantly lower than that of the ormocer and hybrid composites (P < 0.05). Based on the results of this study, it was concluded that the silorane-based composite material could provide a marginal seal comparable to that provided by microhybrid or nanohybrid resin composites.

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**Accepted: March 14, 2012**

**Material and methods**

**Microleakage evaluation**

Twenty-five non-caries extracted human premolars or molars were collected (after debridement) and stored for 7 days in 0.5% chloramine solvent. At that point, the teeth were stored in distilled water at room temperature. Using a high-speed diamond flat end fissured bur (that used water as a coolant), 50 standard Class V cavities were prepared (one on the buccal and one on the lingual surface of each tooth); the preparations included an occlusal margin in enamel and a gingival margin in dentin. The bur was replaced after every fifth preparation. Each preparation was approximately 3 mm x 3 mm x 2 mm. The teeth were distributed randomly into 5 groups (n = 10).

Group 1 samples received a microhybrid resin composite (Tetric Ceram, Ivoclar Vivadent Inc.), with 2 layers of bonding agent (Excite, Ivoclar Vivadent Inc.) applied to the whole cavity surface. The teeth were stored in distilled water at 37°C for 24 hours. Vickers Hardness Number (VHN) measurements were performed using a microhardness tester. Data were analyzed by one-way ANOVA and Bonferroni post hoc tests. In terms of microhardness, there was no statistically significant difference among the resin-based restorative materials (P > 0.05). The degree of microleakage at the gingival margins was lowest for the silorane composite, followed by microhybrid and nanohybrid. The silorane composite was significantly lower than that of the ormocer and hybrid composites (P < 0.05). Based on the results of this study, it was concluded that the silorane-based composite material could provide a marginal seal comparable to that provided by microhybrid or nanohybrid resin composites.
Group 2 samples received a nanohybrid resin composite (Tetric EvoCeram, Ivoclar Vivadent Inc.) and were prepared similar to the samples in Group 1.

Group 3 samples were treated with an ormocer (Ceram X Mono, DENTSPLY Caulk). A layer of bonding agent (Prime & Bond NT, DENTSPLY Caulk) was applied, left for 20 seconds, air-dried for 5 seconds, and photocured for 20 seconds.

Group 4 samples utilized a hybrid-resin composite (Spectrum TPH, 3M ESPE), using the same process as Group 3 samples.

Group 5 samples received a silorane-based composite (Filtek Silorane, 3M ESPE), to which a layer of self-etching primer (Primer 1, 3M ESPE) was applied, left for 15 seconds, air-dried for 5 seconds, and then light cured for 10 seconds.

With the exception of Group 5, that used a self-etching primer, all groups were etched using 37% phosphoric acid, on the enamel and dentin surfaces (enamel = 20 seconds, dentin = 15 seconds). The cavities were rinsed thoroughly with water for 20 seconds and blotted dry, leaving the dentinal surfaces slightly moist. At that point, the bonding procedures were applied. All of the resin-based materials evaluated in this study were used in combination with their respective manufacturers. All preparations, etching, bonding, and procedures were conducted by the same operator. The description of composite materials and bonding agents used are listed in Table 1.

All restorative materials were placed using a bulk technique and photopolymerized for 40 seconds (at 800 mW/cm²) using Coltolux 75. The restorations were then finished and polished with fine-grit finishing diamond burs.

The specimens were stored in distilled water (at 37°C) for 7 days and subjected to thermocycling (at 3,000 cycles) in water baths (5°C-55°C), immersed for 20 seconds and transferred for 20 seconds. After thermocycling, the root ends were sealed with resin composite and the entire surface of each tooth (except for 2 mm around the circumference of the restoration margins) was coated with a clear nonfluorescent nail polish to ensure a perfect seal. At that point, the specimens were immersed for 6 hours into a unimolar silver nitrate solution, rinsed thoroughly, and stored for 12 hours in a photochemical developer. Specimens were exposed to a fluorescent light for 6 hours (to reduce silver ions to metallic silver) and embedded in a transparent self-cure acrylic resin (Meliodent Rapid Repair, Heraeus Kulzer). Using a slow speed diamond saw (Isomet, Buehler) with water-cooling, each specimen was cut vertically in a buccolingual direction through the center of the restoration (Figure).

Marginal leakage was determined with a stereomicroscope (SLX 12, Olympus). A micrometer scale was placed diagonally across each image (1024 x 768 pixels) for calibration and metric assessment of distances.

**Microhardness evaluation**

For specimen preparation, a clear glass slab on top of a dark background was used as a supporting surface and to decrease the reflectivity of the underlying surface toward each specimen. A polystyrene fluorescence light (PTFE) mold (5 mm diameter x 2 mm height) was placed on the glass slab. A total of 25 specimens were made from the 5 resin-based restorative materials groups (n = 5). Initially, the molds were slightly overfilled with material, covered with a plastic matrix strip, and pressed flat with a microscopic glass slide to extrude excess material.

The resin-based restorative materials were photocured continuously with a quartz tungsten halogen curing light (Coltolux 75) at 800 mW/cm² for 40 seconds. The light tip was in close contact with the microscopic slide. The top surfaces of all specimens were wet-ground slightly, using a 1200 grit size silicon carbide paper to remove uncured resin. All specimens were stored for 24 hours in light-proof containers with distilled water (37°C). The microhardness was measured using a microhardness tester (Micromet 2100, Buehler), with a marker for Vickers units. Microhardness indentations were made on the top and bottom surfaces of each specimen. Three readings with a 50 g load for 15 seconds were taken on the top and bottom surfaces of each specimen and the average was converted into a VHN. Hardness ratios were computed within each group by dividing the mean bottom hardness by the mean top hardness.

**Statistical analysis**

To compare the microleakage levels of different composites, a nonparametric Kruskal-Wallis test and a Dunn’s multiple range test were used to analyze the

<table>
<thead>
<tr>
<th>Group (n = 10)</th>
<th>Restorative material (composite)</th>
<th>Adhesive system</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tetric Ceram® (microhybrid)</td>
<td>Excite®</td>
</tr>
<tr>
<td>2</td>
<td>Tetric Evo Ceram® (nanohybrid)</td>
<td>Excite®</td>
</tr>
<tr>
<td>3</td>
<td>Ceram X Mono® (ormocer)</td>
<td>Prime &amp; Bond, NT²</td>
</tr>
<tr>
<td>4</td>
<td>Spectrum TPH® (hybrid)</td>
<td>Prime &amp; Bond, NT²</td>
</tr>
<tr>
<td>5</td>
<td>Filtek Silorane® (silorane)</td>
<td>Bond 2³</td>
</tr>
</tbody>
</table>

¹Ivoclar Vivadent Inc., ²DENTSPLY Caulk, ³3M ESPE
statistical differences among groups. A Wilcoxon signed rank test was used to assess the correlation between the microleakage at buccal and lingual (palatal) surfaces for the resin-based materials. To compare the microhardness level of each composite, the data were analyzed using one-way ANOVA, as the raw data was characterized by a normal distribution based on the one-sample Kolmogorov-Smirnov test.

The statistical operations were performed using computer software (SPSS for Windows 11.5, IBM Corporation). The selected level of statistical significance was \( P < 0.05 \).

Results

Table 2 lists the mean microleakage scores for the various materials tested in this study.

For buccal and lingual (palatal) surfaces, samples in Groups 1, 2, and 5 demonstrated the smallest amount of microleakage at the gingival margins, with no significant difference between the three groups \( (P > 0.05) \); Groups 3 and 4 demonstrated the most microleakage, with no statistically significant difference \( (P > 0.05) \).

Among the resin-based restorative materials tested, statistical analysis showed no significant difference in the microleakage at the occlusal margins of the buccal or lingual (palatal) surfaces \( (P > 0.05) \). There was no correlation between buccal surface microleakage and palatal (lingual) surface microleakage for any of the restorative materials used in this study \( (P > 0.05) \).

Samples in Groups 1 and 5 demonstrated the highest hardness ratios; however, there were no statistically significant differences among the restorative materials in terms of hardness ratio or microhardness of upper and lower surfaces \( (P > 0.05) \). Table 3 lists the mean microhardness values for all groups.

Discussion

Marginal seal is important for the success and longevity of a dental restoration. Dye penetration is the most common method for evaluating the sealing ability of dental materials in vitro.\(^ {13} \) To investigate the effectiveness of resin-based materials in a high C-factor preparation, the present study used a Class V preparation with enamel and dentinal margins.

Silver nitrate—which has been considered suitable for measuring both microleakage and nanoleakage—was used to evaluate microleakage.\(^ {13} \) The silver ion is small (diameter = 0.059 nm) compared to a typical bacterium (0.5–1.0 \( \mu \)m). The ion’s small size, and its high reactivity to stain after binding to exposed collagen fibrils, makes silver nitrate the most appropriate agent for detecting nanoporosities within the hybrid layer.\(^ {14,15} \)

Dental materials are subjected to thermal changes and induced thermal stresses in the mouth, as the different coefficients of thermal expansion in materials and dental structure generate stresses at the interface.\(^ {16} \) A thermocycling protocol was used in the present study to simulate these thermal changes and stresses.

The bonding of resin-based composites to dentin has been known to be a great challenge.\(^ {17} \) However, bonding of resin-based restorative materials to enamel is adequate.\(^ {17} \) In the present study, neither the resin-based restorative materials nor the conventional methacrylate-based composites provided complete marginal seal in Class V cavities. In terms of microleakage, no statistically significant difference was detected between occlusal (enamel) margins at the buccal or palatal surfaces, a finding in keeping with previous studies.\(^ {18,20} \) However, varying degrees of microleakage were reported along the gingival margins in the dentin.

In this study, Tetric Ceram and Filtek Silorane demonstrated the smallest amount of microleakage at the gingival margins, followed by Tetric EvoCeram, with no statistically significant difference between the three composites. These findings are similar to a 2005 study in which a silorane-based composite and a methacrylate-based composite displayed comparable gingival microleakage.\(^ {10} \) Other studies have shown that silorane-based composites show reduced polymerization shrinkage and stress, as well as significantly improved marginal adaptation compared with conventional methacrylate-based composites.\(^ {3,9,21,22} \)

The ring-opening chemistry of silorane produces polymerization shrinkage values <1%.\(^ {3} \) However, the difference in terms of microleakage between Filtek Silorane and the free-radical polymerization of the methacrylate-based resin composites used in this study (Tetric Ceram and Tetric EvoCeram) may indicate modest decreases in the deleterious effects of shrinkage stress.\(^ {10} \) It should be noted that polymerization shrinkage stress depends on a number of factors, including the volumetric shrinkage and elastic modulus of the restorative material, curing speed, the configuration

<table>
<thead>
<tr>
<th>Group</th>
<th>Buccal surfaces</th>
<th>Lingual (palatal) surfaces</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Occlusal (enamel)</td>
<td>Gingival (dentin)</td>
</tr>
<tr>
<td>1 (microhybrid)</td>
<td>12.50</td>
<td>6.50</td>
</tr>
<tr>
<td>2 (nanohybrid)</td>
<td>12.50</td>
<td>11.42</td>
</tr>
<tr>
<td>3 (ormocer)</td>
<td>14.75</td>
<td>20.33</td>
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<tr>
<td>4 (hybrid)</td>
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</tr>
<tr>
<td>5 (silorane)</td>
<td>14.58</td>
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<table>
<thead>
<tr>
<th>Group</th>
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<th>Bottom surface</th>
<th>Hardness ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (microhybrid)</td>
<td>47.38 (5.19)</td>
<td>44.73 (6.2)</td>
<td>95.07</td>
</tr>
<tr>
<td>2 (nanohybrid)</td>
<td>50.50 (4.38)</td>
<td>42.66 (6.73)</td>
<td>85.63</td>
</tr>
<tr>
<td>3 (ormocer)</td>
<td>57.34 (5.22)</td>
<td>40.61 (3.81)</td>
<td>71.28</td>
</tr>
<tr>
<td>4 (hybrid)</td>
<td>48.16 (4.64)</td>
<td>38.04 (4.28)</td>
<td>79.29</td>
</tr>
<tr>
<td>5 (silorane)</td>
<td>46.32 (9.6)</td>
<td>40.98 (3.52)</td>
<td>92.71</td>
</tr>
</tbody>
</table>
of the cavity, and the surrounding tooth tissue. Depending on the configuration, plastic flow may improve during the early phases of polymerization by using less rigid materials and a slower polymerization reaction, reducing polymerization contraction stress with less damage at the adhesive interface. Additional studies are needed to evaluate the effect of these variables on the marginal adaptation of new low-shrinkage resin composites.

In addition to their potential for reduced shrinkage, ormocers have lower cytotoxicity and lower water solubility compared to conventional resin composites. In addition, ormocers demonstrate marginal sealing equal to and even better than methacrylate-based resin composites. Conversely, in the present study, ormocer demonstrated a significantly higher degree of microleakage at the gingival margins than the other methacrylate-based resin composites and the silorane-based composite used in this study.

In a 2001 study, Chen et al found that an ormocer demonstrated a high contraction stress and lower elastic modulus than the other composites tested, due to the fact that ormocers have a more rigid resin matrix. Ormocers have a resin system with inorganic/organic copolymers, producing a high molecular weight that may result in higher residual contraction stress.

In the present study, the ormocer-based Ceram X and Spectrum TPH hybrid composites produced the highest mean microleakage values, with no significant difference between them. One might argue that the adhesive system could affect the marginal leakage of resin-based restorative materials. It should be noted that a 2002 study by Bedran de Castro et al reported that an ormocer material (diffracted carbon double bonds) in turn improves physical properties and microhardness. The results of the present study showed no statistically significant differences among the resin-based restorative materials in terms of upper and lower surface microhardness or hardness ratio. These findings are consistent with previous studies that showed no significant difference between ormocers and conventional methacrylate-based composites. By contrast, previous studies have reported that ormocer-based composites compared to microhybrid composites in a 2010 study, Hahnel et al aged Filtek Silorane, Ceram X, and other methacrylate-based composites artificially for one year, reporting that the Filtek Silorane demonstrated the lowest microleakage values. It should be noted that the results of the present study cannot be compared automatically with previous studies, as the materials, curing lights, exposure times, indentation loads, and storage conditions differ. In addition, the complex oral environment means that the results of this in vitro study cannot necessarily be extrapolated to the clinical situation. Additional long-term clinical studies assessing the performance of new low-shrinkage resin-based restorative materials are required.

Summary

Within the limitations of this in vitro study, none of the resin-based restorative materials evaluated was able to impede microleakage in Class V cavities. Silorane-based composite material could provide an effective marginal seal similar to that of microhybrid or nanohybrid resin composites. Ormocer-based composite and conventional hybrid composites demonstrated significantly greater microleakage at the gingival margins. The microhardness of silorane-based composite was comparable to that of the ormocer and other methacrylate-based composite materials.

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Disclaimer

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Marginal leakage and microhardness evaluation of low-shrinkage resin-based restorative materials


Manufacturers
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Olympus, Center Valley, PA 888.553.4448, www.olympusamerica.com
3M ESPE, St. Paul, MN 888.364.3577, solutions.3m.com

Dental Materials  Marginal leakage and microhardness evaluation of low-shrinkage resin-based restorative materials
The 15 questions for this exercise are based on the article, "Marginal leakage and microhardness evaluation of low-shrinkage resin-based restorative materials," on pages 46-50. This exercise was developed by Steven E. Holbrook, DMD, MAGD, in association with the General Dentistry Self-Instruction committee.

Reading the article and successfully completing this exercise will enable you to:
• recognize the components of low-shrinkage resin-based restorative materials;
• recognize the factors that contribute to their microhardness;
• identify the advantages of reducing polymerization shrinkage in them; and
• understand how they compare to conventional materials.

1. Which restorative material used in this study incorporates a modified monomer matrix in an attempt to reduce polymerization shrinkage?
   A. Composites
   B.Ormocers
   C. Hybrids
   D. Siloranes

2. Which of the following is an inherent disadvantage of a composite restoration?
   A. Inadequate esthetics
   B. Inadequate wear resistance
   C. Inadequate biocompatibility
   D. Inadequate marginal seal

3. The surface hardness was measured utilizing
   A. Knoop hardness values.
   B. Plastic deformation variables.
   C. Vickers hardness numbers.
   D. Kruskal-Wallis testing.

4. A restorative material’s ability to undergo plastic flow during the early phases of polymerization causes a/an _____________ in polymerization contraction stress and ______________ microleakage.
   A. reduction; less
   B. increase; more
   C. increase; less
   D. reduction; more

5. Polymerization shrinkage stress is dependent upon all of the following except one. Which is the exception?
   A. Elastic modulus
   B. Curing speed
   C. Volumetric shrinkage
   D. Bonding agent

6. When compared to conventional resin composites, ormocers exhibit all of the following properties except one. Which is the exception?
   A. Lower shrinkage
   B. Less cytotoxicity
   C. Less rigid resin matrix
   D. Lower water solubility

7. Surface hardness is relevant to all of the following with regard to a restorative material except its ability to
   A. be polished.
   B. Withstand scratching.
   C. Withstand occlusal stress.
   D. Resist polymerization shrinkage.

8. Spectrum TPH and what other restorative material exhibited the greatest amount of microleakage at the gingival margins?
   A. Microhybrid
   B. Nanohybrid
   C. Ormocer
   D. Silorane

9. Which restorative material contains methacrylate-modified silicon dioxide containing nanofiller and a matrix of highly dispersed methacrylate-modified polysiloxane particles?
   A. Hybrid
   B. Nanohybrid
   C. Microhybrid
   D. Ormocer

10. Which of the following materials exhibited the highest hardness ratio?
    A. Microhybrid
    B. Ormocer
    C. Silorane
    D. Hybrid

11. Silorane-based composite material provided a marginal seal comparable to that of microhybrid or nanohybrid resin composites. Silorane-based composite material exhibited a microhardness significantly higher than that of microhybrid or nanohybrid resin composites.
    A. Both statements are true.
    B. The first statement is true; the second is false.
    C. The first statement is false; the second is true.
    D. Both statements are false.

12. Which material exhibited the lowest hardness ratio?
    A. Microhybrid
    B. Ormocer
    C. Silorane
    D. Hybrid

13. The contraction stress associated with polymerization shrinkage can lead to cracks in healthy tooth structure. No statistically significant difference in the hardness ratio was found among the restorative materials.
    A. Both statements are true.
    B. The first statement is true; the second is false.
    C. The first statement is false; the second is true.
    D. Both statements are false.

14. The resin-based restorative materials evaluated were used in combination with ___________________ adhesive system.
    A. a self-etching primer and
    B. total etch and a two-step
    C. a one-bottle
    D. manufacturer’s recommended

15. There is a positive correlation between surface hardness of a resin composite restoration and the
    A. inorganic filler content.
    B. modulus of elasticity.
    C. contraction stress.
    D. plastic flow.

Answer form is on page 80. Answers for this exercise must be received by December 31, 2013.
Two case reports involving implants and fractured healing caps

Erdem Kilic, DDS, PhD • Kerem Kilic, DDS, PhD • Mustafa Zortuk, DDS, PhD • Alper Alkan, DDS, PhD

The widespread use of endosseous osseointegrated implants to replace missing natural teeth increases the chances of implant complications and failures, despite the high initial success rate reported in the literature. Implant and healing cap fracture are possible rare complications that can cause significant problems for both clinicians and patients. This article reports on 2 unique cases of implant and healing cap fracture, their possible causes, and how the cases were managed.

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Dental implants are a functional esthetic solution to partial and total edentulism with an initial success rate of 90%-95%. However, complications can occur in specific situations that affect osseointegrated dental implants. Dentists must be aware of treatment limitations and avoid risky situations that can lead to implant-supported prosthesis failure due to biomechanical complications, such as implant fracture or loosening or fracture of the prosthetic or abutment screws.

Although implants rarely fracture (with an incidence between 0.16% and 1.5%), this complication can present a major problem for patients and clinicians.

This article reports on 2 cases: the first, an implant fracture in a locator attachment-retained overdenture, and the second, a healing cap fracture that was retrieved successfully using an implant repair kit. To the authors’ knowledge, these are the first examples of such cases in the literature.

Case No. 1
A 60-year-old edentulous man was referred for implant treatment. His medical history was unremarkable. Eight implants, all 12 mm long × 3.3 mm in diameter (ITI Dental Implant System, Straumann) were inserted in the region of the lateral incisors and first premolars for maxillary and mandibular arches (Fig. 1). All of the implants achieved good initial stability. After a 3-month preloading healing period with no complications, clinical osseointegration was achieved, and the patient was sent back to the referring prosthodontist for dentures. The patient was treated using an implant-supported overdenture prosthesis, retained with 4 locator attachments by 4 implants for each arch.

The patient underwent maintenance therapy on an irregular basis (approximately once per year). A radiograph taken 1 year after the completion of treatment revealed mild resorption around the implant in the right lateral and first premolar region; no clinical symptoms were evident at that time.

Two years after implant placement, the patient came to the office complaining of discomfort in the right lateral maxilla and loosening of the locator attachment. Clinical examination revealed excessive horizontal movement of the undercut attachment and swelling in the adjacent mucosa. Using very light force, the locator attachment was removed along with the upper third of the implant (Fig. 2); however, the acrylic resin prosthesis was undamaged. Radiographs taken at that time revealed broken edges on the apical part of the osseointegrated implant and noticeable bone loss, coronal to the broken edge of the implant (Fig. 3). The patient had a strong muscle pattern and stated that he slept with the dentures in place; however, he also described a history of tooth grinding.

After clinical and radiographic examinations, 2 treatment options were considered. The dentist could leave the

Fig. 1. Postoperative panoramic radiograph of dental implants 3 months after implant placement.
Fig. 2. The fractured part of the implant with locator attachment.
Fig. 3. A periapical radiograph showing the remaining part of the dental implant. Bone loss can be seen around the implant.
remaining portion of the implant in place and modify the existing denture with 3 locator attachments, or remove the remaining portion of the implant and replace the entire implant with a new one. For economic reasons (and because the patient refused new surgery for the implant placement), the remaining portion of the fractured implant was left in place and the existing denture was modified with 3 locators. Two years later, he reported being satisfied with his modified implant-supported overdenture prosthesis both esthetically and functionally.

**Case No. 2**

A 62-year-old partially edentulous man was referred for implant treatment. His medical history was negative for diseases, injuries, or other treatments. After evaluating clinical and radiographic data, 13 implants (ITI Dental Implant System) were inserted in the edentulous parts of the maxilla and mandible during 1-stage surgery. Healing caps were placed after surgery with no problems.

Ten days later, a mandibular heat-processed acrylic resin removable partial denture (RPD) was adjusted and seated as a temporary prosthesis prior to implant osseointegration. At that point, the patient entered a program of monthly maintenance therapy. Clinical and radiographic examination of the right molar region showed that a healing cap had fractured (according to the patient, while eating) 2 months after implant placement (Fig. 4). There was no damage to the RPD. The apical part of the screw remained threaded into the implant (Fig. 5). The implant was osseointegrated and showed no sign of peri-implantitis. After consulting with the patient, it was decided to remove the fractured screw and restore the implant.

An implant service set (consisting of drills and a drill guide) (Straumann) was used (per manufacturer’s instructions) to remove the apical part of the fractured healing cap that was stuck in the implant. One drill (1.6 mm in diameter) was used counterclockwise (at a speed of at least 600 rpm) along with the respective drill guide. The drill guide was stabilized on the implant and the drill was inserted into the guide (Fig. 6). Drilling was performed under continuous cooling until the shank of the drill reached the guide. It is important to perform intermittent drilling and to eject the metal chips continuously. The fractured screw fragment was not unscrewed, but cut into splinters and removed successfully. The inner aspect of the implant body was rinsed with saline solution and evaluated thoroughly. The entire procedure was completed in approximately 15 minutes. No damage to the implant’s threads was detected (Fig. 7), and a new healing cap was inserted into the implant. After nearly 3 years with the fixed implant-supported prosthesis, no problems have been reported (Fig. 8).
Discussion

Despite high success rates, osseointegrated dental implant therapy is not free from complications. Problems may include implant fracture, which may lead to unpleasant clinical outcomes for both the patient and clinician. As it happens, most authors report a very low incidence of fracture: Mericske-Stern et al found only 1 case in a study of 66 implants, while a 1992 study by Tolman & Laney observed 3 fractures in 1,778 implants. A 1993 report by Jent & Lekholm reported a single fracture out of 259 implants, while Zarb & Schmitt found no fractures in a series of 274 implants. During a 5-year follow-up study, Balshi reported 8 fractured implants in 4,045 implants (0.2%). The cases presented in this article included an implant fracture with a locator attachment and a healing cap fracture. To the authors’ knowledge, these are the first documented instances of such cases in the literature.

Although implant fractures are infrequent, it is important to adopt measures that will prevent them. In this context, dentists should be aware of the possible existence of parafunctional activity, implant location, diameter, and the type of prosthesis involved. According to Balshi, the causes of implant fracture can be divided into 3 categories: defects in implant design or material, a nonpassive fit of the prosthetic framework, and physiological or biomechanical overload. Both overload and a nonpassive fit can cause the prosthetic screw to fracture or loosen before implant fracture. These minor complications are warning signs that should be addressed to prevent future invasive, costly, and time-consuming procedures. According to Eckert et al, implant fractures commonly involve commercial pure titanium 3.75 mm diameter threaded implants, and are typically preceded by the loosening of prosthetics or abutment screws.

Many studies have reported an association between bruxism and implant failure; a 2000 study by Wannfors et al reported a significant relationship between bruxism and implant failure after the implants had been functional for 1 year. Likewise, Glauser et al found a higher percentage of implant loss in bruxism patients (41%) compared to nonbruxism patients (12%) after 1 year. A 2001 study by Bragger et al reported technical implant problems in 60% of patients with bruxism over 5 years, compared to approximately 20% of nonbruxism patients.

In the first case, the implant fracture was attributed to a combination of bruxism, occlusal overload, metal fatigue, and small implant diameter. Signs of parafunctional habits included hypertrophic masticatory muscles and wear of the occlusal and incisal surfaces. Occlusal overload due to parafunctional habits resulted in metal fatigue, which led to implant fracture; in addition, the patient stated that he slept with his dentures in place.

In the edentulous mandible, overdentures supported by a few implants appear to be very successful, while maxillary overdentures are less predictable. Recently, a review of clinical implant studies found that maxillary overdentures produced the highest failure rate (21.3%) for any type of prosthesis. The lower success rates were attributed primarily to the quality of bone in the edentulous maxilla because a looser arrangement of trabecular bone with a thin (or absent) cortical plate generally is considered to be less capable of stabilizing and supporting implants.

A prospective clinical study by Bergendal & Engquist found that ball-retained overdentures resulted in greater implant loss in the maxillary arch (38.8%) than bar-retained overdentures (20.6%). When planning the overdenture, the choice of retention mechanism can be critical for promoting an equitable load transfer within the maxilla. If a bar between implants is loaded, the load is distributed to the bone surrounding the neighboring implants. In the case of solitary attachments (ball attachments), the load is distributed to the bone that surrounds that one implant. Complications with ball attachments occurred in subjects where the implants were not perfectly parallel to each other. The maxillary alveolar bone position means that it is much more difficult to ensure parallel implants in the maxillary arch than in the mandibular arch.

In the first case, the patient was treated with an implant-supported overdenture prosthesis, retained with 4 locator attachments in 4 implants for each arch. The implant in the right lateral maxilla fractured. Based on this case and previous literature, a bar-retained overdenture may be more appropriate within the maxillary arch than a ball-retained overdenture.

Treatment options for implant fractures include removing the implant, modifying the existing prosthesis, and modifying the fractured implant. When implant retrieval can compromise the integrity of adjacent vital structures (due to the proximity to the inferior alveolar canal or adjacent teeth), the least invasive option involves leaving the fractured portion of the implant in place. This approach was taken in the first case and the existing denture was modified with 3 locator attachments, both for economic reasons and because the patient did not want to undergo another surgical procedure.

The following precautions were taken to avoid fracturing another implant: The locator attachments (Straumann) were tightened (per manufacturer’s recommendations), and the patient was given psychological support to overcome the bruxism habit, asked to come back every 6 months for regular follow-up, and cautioned not to wear the prosthesis at night.

In the second case, the healing cap fracture was attributed to a combination of parafunctional habits, as evidenced by hypertrophic masticatory muscles, premature contact between the RPD and the healing cap (due to screw loosening), and the development of metal fatigue (as a result of repeated use of the healing cap). Once a screw fracture has occurred, the fractured screw segment inside the implant must be removed; otherwise, the implant may remain osseointegrated, but will be unable to retain the prosthesis. The fractured part of the healing cap was retrieved successfully using an implant repair kit developed for the ITI Dental Implant System, although it may be used for other implant systems. However, the results from this repair system depend on the individual case. In some situations, failure might result from a reduced interocclusal distance, a restless patient, or a dentist’s inadequate skills.

Roughening the fragment initially and using drill guides for axial drilling helped to reduce the risk of damaging the internal aspect of the implant body. The drill guide should be positioned with great care. Screwing out the perforated fragment was advantageous because the implant threads remained intact; if the threads had been...
damaged, they would have needed to be recut with the tapping instrument. In this case, the fractured healing cap screw was removed successfully and no damage to the threads was detected. To avoid healing cap fractures in the future, it would be appropriate to add a soft lining material to the temporary removable prostheses. In addition, after the fixed implant-supported prosthesis was cemented, the patient was given an occlusal splint to protect the teeth, implants, and restorations from occlusal overload.

A routine patient recall system is very important for avoiding complications (such as screw or abutment loosening), which may constitute an early warning sign of implant or healing cap fracture. Regular recall appointments might prevent further screw or implant fractures because problems could be diagnosed and treated earlier. For this reason, it is essential not only to retrieve the fractured component, but also to determine the reason for the failure and to modify the prosthesis, if necessary.

Conclusion
In this article, the authors presented 2 examples of complications related to implant treatment that have not been reported previously. These complications can be minimized by taking into account certain aspects of treatment such as correct presurgical planning, the use of adequate surgical techniques, postsurgical follow-up, respecting the osseointegration period, appropriate design of the superstructure and correct distribution of occlusal loads. In addition, outcomes of implant treatment would be improved if implant manufacturers offered their own implant service sets for solving these type of complications.

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Disclaimer
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Manufacturer
Straumann, Andover, MA 980.747.2500, www.straumann.com
Dens invaginatus is a developmental abnormality that results from the invagination of the enamel organ into the dental papilla prior to calcification of the tissue. The etiology of this abnormality is unknown at present; however, several factors (including trauma, infection, and genetics) have been suggested as likely causes. Dens invaginatus involves a rare malformation in the primary or permanent dentition. An affected tooth can be normal in appearance or its shape and size may be altered. Dens invaginatus may be assumed when the crown of the tooth is wide and includes a prominent cusp with a palatogingival groove.

The most common classification of this abnormality was proposed in 1957 by Oehlers, who subdivided the condition into three types according to the invagination depth and its connection to the periapical tissue or periodontal ligament. In Type I cases, the invagination extends to the cementoenamel junction. In Type II, the invagination extends beyond the cementoenamel junction and invades the root, but is confined within the root in a manner similar to a blind sac (although it may connect to the pulp). In Type III cases, the invagination extends to the inner root of the tooth to the apical area and has its own foramen in either the apical or lateral region; in addition, the invagination often is connected to the pulp.

Dens invaginatus is a developmental abnormality that alters dental morphology; as a result, treating this condition is a challenge for endodontic practices. This article describes how a combination of nonsurgical and surgical therapies was utilized to treat a maxillary central incisor with Type III dens invaginatus and vital pulp. The treatment plan included using computed tomography (CT) for a detailed analysis of the dental anatomy and periapical area, endodontic and surgical procedures, and a 4-year follow-up period that included periodic clinical and radiographic examinations. The follow-up examinations revealed a regression of the apical lesion and no other signs or symptoms. Based on the present case report, the authors concluded that this combination of surgical and nonsurgical approaches was effective and that CT is a valuable auxiliary tool for the study of dental anatomy.

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Case report
An 11-year-old boy sought treatment, complaining of a fistula with secretions in the vestibular region of the maxillary right central incisor. The crown was enlarged in the vestibule-lingual direction and was characterized by a prominent cingulum. There was no change in the crown’s color. Palpation and percussion tests produced responses within the normal limits; in addition, there was a positive response to the cold test.

It was reported that periodontal treatment had been performed previously in the region— including open-field scraping and regression of the fistula— and symptoms disappeared for approximately 1 year. During a radiographic examination (Fig. 1), an image consistent with Type III dens invaginatus was noted; in addition, the extensive radiolucent image suggested periapical lesions.

Because of the positive response to the cold test, the presence of pulp vitality was considered. To obtain better anatomic details and guide subsequent operative procedures, a CT scan was taken using a 64-channel multislice scanner, Lightspeed VCT (GE Global Research) (Fig. 2). The radiographic and CT images revealed the presence of the main canal located at a distobuccal area, the C-shaped invagination, and the rudimentary canal; in addition, it was possible to define the size of the periapical lesion.

Guided by the radiographic and CT images, a rubber dam was placed and access was made through the mesiolingual aspect of the tooth to reach the invagination and rudimental canal. Therefore,
the endodontic treatment was initiated using biomechanical preparation with a double-flared technique, using first and second series stainless steel K-type files (DENTSPLY Maillefer) and abundant irrigation with 2.5% sodium hypochlorite. Upon completing the biomechanical preparation, a paste made of calcium hydroxide and 2% chlorhexidine digluconate was used as an intracanal medication. The paste was replaced once a month for the next 3 months.

Based on the extent of the lesion and the lack of fistula regression after 3 months, it was decided to perform endodontic surgery with a transoperative root obturation. After anesthesia, incision and dilatation procedures were performed; at that time, the presence of cervical bone resorption was observed to the level of the middle third vestibular region of the tooth (Fig. 3). During the osteotomy, the collected bone was placed in a container with saline solution. Later, the bone was mixed with lyophilized bone substitute (Bio-Oss, Geistlich Pharma North America Inc.) to fill the surgical site.

The periapical lesion was removed using a Lucas curette. Next, master cones were prepared for invagination and rudimental canal obturation. An epoxy resin sealer containing calcium hydroxide (AH 26, DENTSPLY Maillefer) was used to fill the area, while Microseal (SybronEndo) was used as the obturation system. To make space for the root-end filling, 3 mm
of the obturation was removed apically and white mineral trioxide aggregate (MTA) cement was applied.

After the MTA cement set initially, the region was irrigated extensively with saline. The bone area was filled with the lyophilized Bio-Oss and previously collected bone. In addition, a biological membrane of bovine origin (Bio-Gide, Geistlich Pharma North America Inc.) was placed on the vestibular face of the tooth. The flap was repositioned and secured with a 4.0 suture.

During a 4-year follow-up, which included periodic examinations, the pulp continued to provide positive responses to pulp sensibility testing. The responses indicated that the pulp in the main root canal had survived. To evaluate the long-term success of the treatment, a cone-beam volumetric tomography scanner (i-CAT, Imaging Sciences International) was used to take a CT scan at the final examination (Fig. 4 and 5).

Discussion
Endodontic treatment of dens invaginatus is highly complex, especially in Type III cases, as the invagination extends to the apical region of the tooth and is associated with the presence of a lesion.6 It has been described in the literature as an isolated canal; however, the literature also has reported several cases of dens invaginatus with involvement of vital pulp tissue.5,10-13,24,25 In these studies, only the invagination received endodontic treatment, while the main canal remained intact, as seen in the present case.

Some studies have reported successfully preparing cases of Type III dens invaginatus by using manual files, nickel titanium (NiTi) rotary instruments, and ultrasonic files.5,8,10,25,26 However, the use of rotary instruments is not recommended because of the enamel line inside the invagination and because invaginations usually have an irregular shape and rotary instruments would increase the risk of fracture.22 Manual files were chosen for safety reasons. The CT images revealed the anatomical details of the invagination, including the extent and location of the palatine apical lesion. This information was critical to executing the treatment plan, as these images provided data that could not be found using conventional radiography.10,11,16

In the present case, surgical supplementation was considered due to the persistence of the fistula, which indicated that the invagination was not decontaminated. It is possible that irregularities in the invagination may have prevented the necessary direct contact between the therapeutic agent (calcium hydroxide) and microorganisms. The bone resorption at the vestibular root also may have contaminated the periapical tissues, contributing to the fistula’s inability to regress.

Previous studies have reported that the sealing capacity of thermoplastic methods makes them an ideal choice for filling the root canal system.27,28 The Microseal system, which combines a gutta-percha master cone with thermoplastic gutta-percha, was used in the present case.29

MTA often is used as a root-end filling material because of its ability to induce the formation of mineralized tissue in the root apex region; in addition, it offers antimicrobial qualities, sealing ability, and adequate biocompatibility.19-21 These proven clinical and histological properties led the authors to use MTA as the root-end filling material in the present case.

Summary
Based on the clinical and radiographic features observed during this case, it is reasonable to assume that a combination of surgical and endodontic treatments is a valid option for successful treatment of Type III dens invaginatus. It also should be emphasized that CT scanning plays an important role in the study of dental anatomy and adjacent areas, and it may contribute to the treatment of complex dental anatomical abnormalities.

The use of CT images to understand the complexity of the dens invagination anatomic details as well as to assist in the surgical supplementation were critical to the success of this treatment.

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Obesity and periodontitis: a link
Charlene B. Krejci, DDS, MSD • Nabil F. Bissada, DDS, MSD

Obesity and periodontitis are both diseases that represent significant health problems. Obesity currently impacts approximately one-third of the US population and periodontitis affects an estimated 50% of the same population, ages 30 and over. It has been suggested that the possible relationship between obesity and periodontitis lies in the diseases’ underlying inflammatory processes. The aim of this paper is to present those inflammatory pathways and to review the literature that has examined the association between obesity and periodontitis.

Obesity, defined as a body mass index (BMI) ≥ 30.0 kg/m², is a major public health problem and, according to the latest National Health and Nutrition Examination Survey (NHANES) data from 2007-2008, has a documented prevalence in the United States of 32.2% among adult men and 35.5% among adult women.¹,² Obesity is a systemic disease that has been identified as a risk factor for the development of hypertension, type 2 diabetes, cardiovascular disease, dyslipidemia, certain forms of cancer, respiratory problems, and, most recently, periodontitis.³

Periodontitis, by definition, is a chronic inflammatory disease of bacterial origin that affects the surrounding and supporting structures of the teeth and remains one of the most ubiquitous diseases of mankind, affecting an estimated 50% of the US population over the age of 30.⁴,⁵ It is believed that the destructive process of periodontitis begins with the accumulation of subgingival plaque biofilms and the subsequent release of toxic products from the pathogenic plaque bacteria. The host’s response to these bacteria and their toxic products triggers an inflammatory response that can cause gingival ulcerations, tissue destruction, alveolar bone loss, and tooth loss. This results in the local production of cytokines and other biological mediators along with an increase in the concentration of systemic inflammatory markers. Emerging scientific evidence indicates a possible link between periodontitis and a number of systemic diseases, including cardiovascular disease (CVD), adverse pregnancy outcomes, diabetes mellitus, respiratory disease, osteoporosis, rheumatoid arthritis, certain forms of cancer, and obesity.⁶-¹²

The inflammatory pathways
It is well documented that adipose tissue is not simply a repository for fat cells, but is a metabolically active organ that secretes more than 50 bioactive substances, including pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6), both of which are the main inducers of acute phase hepatic protein production including that of C-reactive protein (CRP).¹³,¹⁴ Obese individuals have been reported to have elevated levels of circulating TNF-α and IL-6 as compared to normal-weight controls; TNF-α, IL-6, and CRP are closely related to obesity and insulin resistance.¹⁵,¹⁶ Leptin, a 16-kDa non-glycosylated polypeptide that acts as both a cytokine and a hormone, is also produced by adipose tissue and is involved in a multitude of biological processes including energy metabolism, endocrine functions, reproduction, and bone metabolism.¹⁷ Leptin functions as a circulating appetite suppressant that regulates adipose tissue mass through a negative feedback system.¹⁸ Elevated leptin levels result in decreased food intake, increased energy expenditure, and a negative energy balance whereas leptin deficiency results in hyperphagia and severe obesity.¹⁹ However, obese individuals generally exhibit unusually high levels of circulating leptin, which suggests a resistance to leptin in much the same way individuals with type 2 diabetes are resistant to insulin.²⁰ In addition to leptin’s role as an appetite regulator, several studies have clearly demonstrated that it plays a significant role in the inflammatory process and there is a consensus of opinion that regards leptin as a pivotal pro-inflammatory agent. An increase in leptin production occurs during infections and inflammatory processes and is therefore implicated in the pathogenesis of chronic inflammatory diseases.²¹-²³

Periodontitis, as noted above, is a chronic inflammatory disease whose bacterial origin and resultant endotoxin production can trigger host responses at both the local and systemic levels.²⁴ Inflammatory mediators, including interleukins (IL-1β, IL-6, IL-8, IL-17, and IL-23) and TNF-α, as well as bone-related factors, have been identified in periodontal tissues at both the mRNA and protein levels.²⁵ In periodontitis, the proinflammatory actions of TNF-α contribute to bone loss and the loss of periodontal attachment; the pro-inflammatory actions of IL-17 contribute to the production of other proinflammatory mediators including IL-6 and IL-8 and has also been implicated in alveolar bone destruction.²⁶-²⁸ Beck et al reported an up to tenfold increase in local and systemic inflammatory cytokines including TNF-α and IL-6 in some subjects with periodontitis.²⁹ These same cytokines can then trigger an increase in the production of acute phase proteins such as CRP, which results in an upregulation of the inflammatory response similar to that seen in obesity. In a study by Gomes-Filho et al., levels of CRP were higher in patients with periodontitis as compared to patients without the disease.³⁰ Similarly, higher levels of serum leptin have been associated with increased periodontal destruction.³¹-³³ It is increasingly clear from the periodontal literature that it is the host response, rather than the bacteria, that drives the inflammatory processes both locally and systemically.³⁴-³⁶ Failure to contain the local inflammatory response, along with research documenting the presence of inflammatory mechanisms in most of the chronic diseases of aging, has...
led researchers to explore the commonality of the inflammatory pathways and to suggest a possible bidirectional link between periodontal disease and multiple chronic diseases—including obesity.

The literature

The relationship between obesity and periodontitis was first reported by Perlstein & Bissada in 1977 when histopathologic changes were observed in the periodontium of obese rats subjected to ligature-induced periodontitis.37 In response to plaque accumulation, periodontal inflammation and alveolar bone resorption were found to be greater in the obese rats as compared to nonobese controls.

In humans, an association between obesity and periodontitis was first reported in an epidemiological study conducted by Saito et al in Japan using 241 healthy individuals to which the community periodontal index of treatment needs (CPITN) was applied.40 After adjusting for confounding variables, they found that the relative risk for periodontitis was 3.4 in persons with a BMI of 25-29.9 kg/m² and 8.6 in those with a BMI ≥ 30 kg/m².38 An additional study by Saito et al utilizing 643 Japanese individuals who had at least 1 tooth per sextant with a probe depth of ≥4 mm showed that high upper-body obesity and high total body fat were associated with a higher risk of periodontitis as compared to normal weight individuals.39 A longitudinal study recently published by Morita et al involving 2,787 Japanese men and 803 Japanese women, whose BMI and the incidence of periodontal disease as defined by a probing depth >4 mm, were evaluated over a 5-year period.40 The study reported that the men and women in the BMI groups of 25-29.9 kg/m² and ≥30 kg/m² were statistically more likely to develop periodontitis than those whose BMI was <22 kg/m².40 Moreover, these findings demonstrated a dose-response relationship between BMI and the development of periodontal disease in the population studied.

In a large cross-sectional study utilizing data from the Study of Health in Pomerania (SHIP), the impact of obesity on inflammation in both dentate and edentulous subjects was evaluated through anthropometric measurements including BMI and waist-to-hip ratio (WHR), along with diagnostic periodontal parameters and systemic markers of inflammation.41 The results indicated that obesity was associated with both the extent and severity of periodontal disease along with markers of systemic inflammation. These associations were characterized by a strict dose-effect relationship between WHRs and periodontal attachment loss, and between serum CRP and fibrinogen levels or white blood cell (WBC) count. When adjusted for age, sex, smoking, diabetes, education, physical activity, and last dental appointment, it was found that serum CRP, fibrinogen, and WBC count were significantly correlated to WHR ($P < 0.001$), as well as to the BMI, in dentate and edentulous subjects.41

An analysis of the NHANES III data involving 13,665 individuals having one or more sites with clinical attachment loss (CAL) of ≥3 mm and probe depths of ≥4 mm was completed by Genco et al, and a positive correlation was found between BMI and the severity of periodontal attachment loss.42 Al-Zahrani et al and Wood et al analyzed the same data from different perspectives and found that fat in general, as well as specific fat distribution patterns, could be correlated with periodontal disease.43,44 Recently, Kim et al conducted a cross-sectional study of Korean adults using the Fourth Korean National Health and Nutrition Examination Survey (KNHANES) and found a significant association between abdominal obesity as measured by waist circumference and periodontitis; correlations between BMI and periodontitis were not as strong, however, thus lending credence to the possibility that it may be the location of body fat, not the overall amount, that has a greater association with periodontitis.45

Another analysis of the NHANES III data that was undertaken by Al-Zahrani et al in 2005 found that individuals who maintained normal weight, exercised regularly, and followed a diet utilizing the US Department of Agriculture Center for Nutrition Policy and Promotions’ Food Guide Pyramid and Dietary Guidelines for Americans were 40% less likely to have periodontitis.46

In a recent study by Lakki et al, 30 obese individuals with at least 20 teeth who were also affected by chronic periodontitis as defined by a mean periodontal attachment loss of ≥2 mm were evaluated with respect to bariatric surgery, weight loss, and periodontal disease.47 All patients underwent nonsurgical periodontal therapy involving oral hygiene instructions, scaling, and root planing. Of the 30 patients, 15 underwent bariatric surgery and lost at least 40% of their excess weight while the remaining 15 patients served as controls. At the end of the study period, a statistically significant improvement was noted in the periodontal status of those who underwent bariatric surgery and lost weight over those who did not. This represents the first interventional pilot study that clinically demonstrates the bidirectional interaction between these two disease conditions.47

An extensive review of the periodontal literature was undertaken by Chaffee & Weston to systematically compile studies that examined the relationship between obesity and periodontitis.12 The result of their literature search was a quantitative summary of the association between these two disease states. Of the 554 citations found in the literature, 70 studies representing 57 independent populations met the inclusion criteria, nearly all of which were cross-sectional in design. Of the 70 studies included, 41 suggested a positive association. Findings suggested a higher mean BMI among periodontal patients, a greater mean attachment loss among obese individuals, and a trend toward increasing odds of periodontal disease with increasing BMI. As noted by the authors, however, cross-sectional studies represent only a moment in time and—while able to show an association between obesity and periodontitis—cannot therefore show evidence of causality.12

Conclusion

In an overview of periodontics and obesity, whether one condition stands as a risk factor for another or whether one disease causes another has yet to be elucidated. What has emerged from the literature, however, is that an association between obesity and periodontitis exists and that association most likely lies in the commonality of their inflammatory pathways. According to Genco, the relentless release of pro-inflammatory cytokines into the systemic circulation from adipose tissue in obese individuals provides a systemic inflammatory overload.48 These cytokines may directly

www.agd.org General Dentistry January/February 2013 61
injure the periodontal tissues or reduce the vascular blood flow to the periodontal tissues, as first suggested by Perlstein & Bissada, thus promoting the development of periodontitis. Periodontitis, itself an inflammatory disease, induces its own set of cytokines both locally and systemically in response to bacterial pathogens and endotoxins and thus adds to the level of circulating proinflammatory mediators (Chart). As such, periodontitis increases the systemic level of inflammation and thus may contribute to systemic inflammatory diseases and a bidirectional link. Long-term prospective studies are needed to further elucidate specific cause and effect relationships between obesity and periodontitis as well as to the wider body of other chronic inflammatory diseases.

In the interim, health care professionals need to be cognizant of the complexity of obesity and its relationship to multiple health care issues while at the same time giving credence to the role of periodontitis to overall health. This necessitates the full cooperation and collaboration of all health care professionals, in whatever capacity, to educate patients regarding the ramifications of obesity and periodontitis and to encourage counseling, treatment, and intervention strategies as needed.

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Exercise No. 323  Periodontics  Subject Code 490

The 15 questions for this exercise are based on the article, Obesity and periodontitis: a link, on pages 60-63. This exercise was developed by Gustav Gates, DDS, MAGD, in association with the General Dentistry Self-Instruction committee.

Reading the article and successfully completing this exercise will enable you to:
• understand the current information regarding the link between obesity and periodontitis;
• understand the role of inflammatory pathways connecting periodontitis to obesity; and
• review the current literature on obesity and periodontitis.

1. A person who has a body mass index (BMI) of _____ is considered obese.
   A. 15  
   B. 22  
   C. 29  
   D. 36

2. In the United States _____% of adult men and _____% of adult women are considered obese.
   A. 15.8; 16.9  
   B. 18.2; 21.3  
   C. 28.6; 29.4  
   D. 32.2; 35.5

3. Obesity is a systemic disease which has been identified as a risk factor for development of all the following except one. Which is the exception?
   A. Hypertension  
   B. Type 1 diabetes  
   C. Cardiovascular disease  
   D. Dyslipidemia

4. Elevated leptin levels in healthy individuals have been shown to
   A. increase food intake.  
   B. create positive energy balance.  
   C. increase energy expenditure.  
   D. cause hyperphagia.

5. Obese individuals generally exhibit unusually high levels of circulating leptin. This suggests a resistance to leptin in much the same way individuals with type 2 diabetes are resistant to insulin.
   A. Both statements are true.  
   B. The first statement is true; the second is false  
   C. The first statement is false; the second is true.  
   D. Both statements are false.

6. Adipose tissue has been shown to be a metabolically active organ. It has been shown to do all of the following except one. Which is the exception?
   A. Be a repository for fat cells  
   B. Secrete over 50 bioactive substances  
   C. Secrete C-reactive protein (CRP)  
   D. Secrete proinflammatory cytokines

7. Leptin is produced by the adipose tissue. It is involved in all of the following except one. Which is the exception?
   A. Reproduction  
   B. Energy metabolism  
   C. Exocrine function  
   D. Bone metabolism

8. In periodontitis, the proinflammatory actions of TNF-α contribute to the loss of attachment. One inflammatory mediator that has been implicated in alveolar bone loss is IL-17.
   A. Both statements are true.  
   B. The first statement is true; the second is false  
   C. The first statement is false; the second is true.  
   D. Both statements are false.

9. It has become increasingly clear from the periodontal literature that bacteria drive the inflammatory process. Levels of CRP are lower in patients with periodontal disease.
   A. Both statements are true.  
   B. The first statement is true; the second is false  
   C. The first statement is false; the second is true.  
   D. Both statements are false.

10. The relationship between obesity and periodontitis was first reported by _____ in 1977.
    A. Offenbacher & Beck  
    B. Carroll & Flegel  
    C. Perlstein & Bissada  
    D. Carroll & Beck

11. An analysis of the data from the United States NHANES III survey found that an individual was 40% less likely to have periodontitis if they did all of the following except one. Which is the exception?
    A. Maintained normal weight  
    B. Exercised regularly  
    C. Followed the Food Guide Pyramid  
    D. Took 3000 IU of vitamin C daily

12. A study of patients who underwent bariatric surgery and lost_____% of their excess weight had a statistically significant improvement in periodontal status.
    A. 10  
    B. 20  
    C. 30  
    D. 40

13. Chaffee & Weston found 70 studies that examined the relationship between obesity and periodontitis. Of the 70 studies, _____ suggest a positive association between the two.
    A. 24  
    B. 35  
    C. 41  
    D. 56

14. Analysis of the Fourth Korean National Health and Nutrition Survey found a significant association between _____ and periodontitis.
    A. location of body fat  
    B. age of patient  
    C. dental visits per year  
    D. socioeconomic status

15. By definition, periodontitis is an acute inflammatory disease of bacterial origin. It affects <30% of the United States population 30 years of age and over.
    A. Both statements are true.  
    B. The first statement is true; the second is false  
    C. The first statement is false; the second is true.  
    D. Both statements are false.

Answer form is on page 80. Answers for this exercise must be received by December 31, 2013.
Surgical resection and prosthetic treatment of an extensive mandibular torus

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Renata Cunha Matheus Rodrigues Garcia, DDS, MSc, PhD

The aim of this case report was to describe the surgical removal of an extensive mandibular torus and the conventional prosthetic treatment that was performed. During surgery, the torus was exposed by an intraosseous lingual incision from molar to contralateral molar side and displacement of the mucoperiosteal flap. The bone volume was carefully removed in 3 separate blocks by sculpting a groove in the superior lesion area and chiseling. After a 30-day postoperative period, a prosthetic treatment was performed using a conventional distal extension removable partial denture. The patient’s esthetic and functional expectations were achieved. The surgical procedure and prosthetic treatment performed in the treatment of the mandibular torus in this clinical case is a viable treatment that produces few complications and re-establishes normal masticatory function.

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A torus is a local bone hyperostosis formed at the longitudinal ridge of the half palatine (palatine torus) or on the mylohyoid line on the lingual surface of the mandibular body (mandibular torus).\(^1,2\) This benign bone projection presents varying slow and progressive growth, due to the asymptomatic nature of the lesion, and is usually incidentally diagnosed during a routine clinical examination.\(^3,5\)

Clinically, a mandibular torus commonly emerges in the premolar region above the mylohyoid attachment; however, it can be distally extended to the third molar area and mesially toward the lateral incisor.\(^1,5,6\) A normal but thin mucosa covers this bone projection, and ulcerations can occur if the region is traumatized, especially in the case of extensive lesions.\(^1,4\)

Imaging examinations (for example, X-ray or CT) of mandibular tori reveal that a circumscribed radiodense region often encroaches upon the roots of premolars and molars, impairing the observation of tooth details.\(^1,4\) Histological aspects show cortical and cancellous bone, which form as a result of lamellar periosteal outgrowth of the mandible; presence of the spongy layer is very rare and is present only in large tori.\(^1,5\) Mandibular tori are classified according to size as either small (<2 mm), medium (2-4 mm), or large (>4 mm).\(^7,8\)

Tori are usually (61%) nodular in shape; 87% of tori emerge unilaterally or bilaterally, in single or multiple forms.\(^3,6,7\) The prevalence of mandibular tori is 2.1%; however, only 1% of palatine tori can be seen in patients at a mean age of 49.\(^10\) Although the prevalence of mandibular tori does not differ between males and females, some ethnic groups, such as Eskimos, Japanese, and North Americans, demonstrate a higher prevalence index, suggesting a multifactorial etiology.\(^3,6\) There is evidence that there are environmental influences on torus development, such as nutritional disturbances, dietary habits (including the use of calcium supplements and diets rich in vitamin D), side effects of continuous phenytoin use, and masticatory hyperfunction.\(^6,7,11,16\) Eggen & Natvig, using logistic regression, proposed another theory that 30% of torus etiology is genetically determined (due to a dominant autosomal gene on the X chromosome).\(^7\)

Mandibular and palatine tori must be surgically removed when they present with superficial mucosal ulceration and food retention, and when they interfere with esthetics, speech, or prosthetic rehabilitation.\(^1,3,5,9,15,17\) Other aspects that must be considered regarding torus surgical excision include whether the area is associated with infectious processes, such as osteomyelitis, or neoplastic processes, such as carcinomas.\(^4\)

In an effort to inform dentists of the possible complications of torus removal, this article presents a clinical report on the surgical removal of an extensive mandibular torus and the prosthetic treatment performed afterward.

Case description
The patient, a healthy 45-year-old man with leukoderma, was referred to the Piracicaba Dental School, State University of Campinas (FOP-UNICAMP) for general and prosthetic treatment. The subject was completely dentate in the maxilla and partially dentate in the mandible, so he was classified as Kennedy Class II, modification 1 (Fig. 1 and 2).

At the clinical examination, a highly extensive mandibular nodular torus (>4 mm on each side) was detected bilaterally in the premolar and molar area. The lesion was not painful; however, the patient reported discomfort due to its volume, which altered speech. The patient also reported difficulties with oral hygiene, due to areas of food retention, and consequent halitosis. Teeth adjacent to the torus were vital without alterations in sensitivity and had healthy marginal periodontium. The torus lesion was covered by attached gingival tissue with normal color, continuity, and volume.

Periapical and occlusal radiographs of the patient’s remaining teeth were taken. The resulting images confirmed the health of the teeth next to the lesion as well as an increase of bone volume in the lingual area, beginning in the canine apical region and extending bilaterally to the molars, in correspondence with the torus.

After the imaging procedures, complete maxillary and mandibular arch impressions were made using irreversible hydrocolloid impression material (Jeltrate, Dentsply International) and stock trays (Tecnodent Industria e Comercia). Diagnostic casts were processed using Type III dental stone (Herodent, Vigodent S/A Industria e Comercio) and were manually articulated in the maximum intercuspal...
position and fixed using a dental sticky wax (Asfer Industria Quimica). Afterward, the pair of casts was mounted on a semi-adjustable articulator (Gnatus 8600, Gnatus) with the help of the facial bow of the articulator device. A removable partial mandibular prosthesis was the chosen treatment in the present case; its advantages include the possibility of replacing a greater number of missing teeth, ease of cleaning, and low cost. Implant therapy was not recommended due to the low quality of the bone in the torus area, which could have resulted in a weak osteogenic capacity of the torus bone. Moreover, the high density and slight vascularization of the bone in the torus region could produce excess heat and tension during implant placement, which could influence implant longevity. Due to the dimensions of the torus, the proposed treatment was surgical removal of the lesion, including an excisional biopsy, followed by the insertion of a removable partial mandibular denture.

The surgical procedure was performed in the surgical center of FOP-UNICAMP under local infiltration anesthesia. The first step was an intrasulcular lingual incision from molar to contralateral molar side and displacement of the mucoperiosteal flap, exposing the entire lesion (Fig. 3). Bone volume was removed by making a groove in the superior lesion area with a 702 bur (KG Sorensen). The entire lesion was cleaved into three separate blocks. Once the torus had been removed, the area was smoothed with a large round bur (KG Sorensen) under saline rinsing, and the surgical site was irrigated to clean bone debris (Fig. 4). The surgical procedure was concluded with local suturing.

During the postoperative period, the patient was given aftercare instructions regarding medication (analgesic), diet (soft and liquid food), and hygienic care (tooth brushing and cleaning of the surgical area). Ten days after the surgical procedure, the sutures were removed, and a 30-day healing period was allowed (Fig. 5). The oral cavity was then prepared for the prosthesis. Occlusal rest seats were performed on the mesial marginal ridge of the left second premolar, the distal marginal ridge of the right second premolar, and the mesial marginal ridge of the right second molar. Guide planes and additional retentions were not necessary. A definitive impression was obtained using Jeltrate, and a custom tray was fabricated using autopolymerizing acrylic resin (Classico, Artigos Odontologicos Classico Ltda.). The final master cast was prepared using Type IV dental stone.
The present case report describes the excision of an extensive mandibular torus from an otherwise healthy patient. The most common treatment of a mandibular torus is long-term clinical monitoring, as most are small and do not cause oral damage. However, because the patient in the present case revealed discomfort during speech and the hygiene process, and given that the size of the lesion could affect the insertion of any prosthetic device, resulting in prosthesis instability and chronic tissue irritation, it was decided to perform the surgical procedure.

Currently, several options exist for rehabilitation of such clinical cases, including removable prostheses, more complex treatments such as implant-supported dental prostheses, and combinations of these therapies.

However, some subjects may not have access to implant treatment or may not be physically capable of receiving it. Moreover, despite the fact that studies have revealed that the torus bone can be indicated as autogenous graft material for implants, the large amount of dense cortical bone in the torus area is likely to implant placement due to the weak osteogenic capacity of torus bone.

Although the technique presented here is simple, there can be complications with surgical excision of the torus. Generally, these can occur when the mucoperiosteum is lifted, leading to sectioning of the Wharton or submaxillary duct, or lacerations of the floor of the mouth or other anatomical structures that could require surgical repair. The surgical procedure must be performed carefully in order to avoid damaging the inferior alveolar or lingual nerves, which can result in paresthesia. Postsurgical precautions must also be taken to prevent infections that could worsen the patient's prognosis or require additional procedures.

In some severe cases, the use of general anesthesia is necessary and could represent an operative risk. However, a thorough knowledge of anatomical structures in the oral region and the proper use of instruments will prevent most complications.

A mandibular torus is typically encountered during a routine examination, and while complications are rare, they can occur as a result of the clinician's iatrogenic surgical maneuvers. For this reason, clinical dentists must be acquainted with and able to treat this common lesion in a predictable, optimized way.

Summary

Mandibular torus removal must be considered when traumatic ulcers resulting from mastication are noted, when the lesion volume interferes with normal speech or tongue functions, or when prostodontic considerations are required. In the present case report, conventional excision of the lesion was performed without surgical complications and a good prognosis was made after rehabilitation with a removable partial denture.

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Occlusion confusion

Gene McCoy, DDS

The subject of occlusion is fraught with controversy and confusion. As a result, there is no consensus on occlusal morphology, normal function of the mandible, or occlusion’s relationship to temporomandibular joint (TMJ) disorders. The purpose of this paper is to explain the reasons for the controversy and to provide suggested guidelines, based on engineering principles, for the restorative dentist to follow in order to minimize and prevent TMJ-related problems.

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Most dentists agree that a good understanding of occlusion is essential to ensuring optimal dental health; however, that seems to be the only point of consensus for this important, controversial subject. As Gordon Christensen stated in a letter (November 6, 2008), “Unfortunately, occlusion in its broad definition is not a popular subject in continuing education courses or in actual practice. Although occlusion principles permeate almost all of dentistry, the area is confounded by confusing theories, non-practical techniques, contradictory ‘beliefs,’ and practitioners unaware of the basic concepts of occlusion. As a result, most dental patients go without the benefits of dental therapy based on several misleading occlusal assumptions.” These “misleading occlusal assumptions” inspire an important question: What is the precise role that occlusion plays in the etiology of temporomandibular joint (TMJ) disorders?

How many times have you heard someone blame a restorative failure on the occlusion? It might be worth asking what that means, since the word occlusion has three different interpretations. The original definition referred to the act or process of occluding (from the Latin occludere, which means to “shut up” or “close up”). As a result, dental occlusion was originally defined as the relation of the teeth when the jaws are closed. In 1959, the definition was expanded to mean “the contact of the teeth of both jaws during those excursive movements of the mandible essential to the function of mastication.” This new definition was published even though early studies suggested that teeth rarely touch during mastication (and when they do touch, they do so only lightly) and that excursive movements of the mandible are not essential to mastication. The dental profession had witnessed patients grinding their teeth in lateral excursions, saw that it was doing damage, and sought to find the horizontal vector with the least resistance or interference. Although it may have been assumed that these horizontal excursions were an integral part of normal function, they were actually examples of parafunction. People do not normally eat in horizontal excursions unless forced to do so by a flattened dentition. Still another interpretation of occlusion was Jablonski’s definition that, instead of simply describing the way teeth touch each other, developed into a 60-word description of all the components of the stomatognathic system.

Current texts on occlusion do not merely describe the simple touching of maxillary and mandibular teeth, but rather present a detailed analysis of the whole stomatognathic system. Occlusion (that is, the way teeth touch each other during closure) and the stomatognathic system are entirely different things and should be described separately to remove any ambiguity.

The function of the stomatognathic system

When defining occlusion, the confusion stems from the fact that there are two entirely different viewpoints as to how the stomatognathic system should function. With the vertical function paradigm model, the mandible functions vertically. People speak vertically, swallow vertically, and eat vertically. The vector of mastication is a vertical teardrop with a lateral movement of 5-6 mm during the first phase of chewing; as the teeth approach each other, the lateral displacement is reduced to 3-4 mm from the starting position. During closure, the mandible is guided into position by the occlusal incline planes of the teeth. It is not a consistent and reproducible movement, but a function of head position. As the head tilts forward, the mandible goes forward; after each vertical function, the mandible returns to a state of physiological rest.

During opening and closing, there is condylar centricity where the axis is maintained; upon complete closure, the condyles are seated in the anterior-superior portion of the glenoid fossae. There are seldom any border movements and most mandibular movements take place within a reasonably limited 3-dimensional space. The model in this paradigm is free from parafunction. While there is no disagreement that speaking and swallowing occur vertically, the horizontal paradigm is based on the premise that the mandible functions laterally rather than vertically. This paradigm was first developed in the early 20th century when a number of dentists became preoccupied with the mandible’s ability to rotate around axes in three planes. It was the objective of the gnathologists who studied these jaw movements to produce a proper occlusal form that would be dictated by mandibular movements—in other words, one that would accommodate free passage for the opposing dentition by eliminating interferences in laterotrusion movements from centric. This goal was defined as optimal functional occlusion.

This definition conflicts with the definition of functional occlusion, which refers to the touching of maxillary and mandibular teeth during mastication and deglutition. Both activities are vertical, not horizontal. In other words, function in lateral excursions is actually parafunction. The anterior teeth are a major interference for anterior excursions; to eliminate that obstacle, it would be necessary to
shorten the incisors considerably. The gnathologists’ solution was to declare that the purpose of the anterior teeth being longer was to disengage the posterior teeth during these parafunctional excursions for their protection, a principle referred to as anterior guidance, which is half of the concept of protected articulation. Nothing was said about the trauma that the anterior teeth would receive during this exercise.

In the author’s opinion, the vertical paradigm, free from parafunction, is the model to emulate. If parafunction occurs, treatment should focus on management and prevention rather than accommodation.

**Morphology of the dentition**

Three key benchmarks are used to evaluate the overall status of the stomatognathic system: the muscles of mastication, the condyle, and the dentition. When the system is healthy and functioning efficiently, the muscles of mastication are relaxed and the condyles are seated properly in the anterior superior part of the fossae. However, there is no consensus regarding the morphology of the dentition, how the maxillary and mandible should contact each other in closure, and more importantly, the dentition’s involvement in temporomandibular disorders (TMDs).

There are design principles that appear to govern the structure-function relationship in organisms; that is, there is an interface between mechanical engineering and biology which indicates that biological materials and structures are designed for specific functions. Teeth are a perfect example of a structure-function relationship. The fossae are intended to hold food for cutting, while the sharp cusps have two purposes: to cut the food and to direct mastication forces vertically down the long axis upon closure.

The space between the incline planes allows for resistance-free repositioning of the mandible/condyle during swallowing and anterior posterior postural changes. It would appear that the original design or morphology of our teeth is best suited to serve our stomatognathic system; unfortunately, not everyone emulates this standard. For instance, when constructing removable dentures, seven different designs are available for the posterior teeth, with occlusion ranging from 33° to 0° (flat plane).

Two developments programmed the dental community for the concept of flat plane occlusion: the gnathologists’ horizontal function paradigm—research which suggested that 33° of occlusion would be harmful to the alveolar bone—and the perception that people were designed to eat with a flattened dentition. In research conducted by Ortman, Kydd, Regli & Kydd, and Swoope & Kydd, investigators placed strain gauges in dentures and had patients eat various types of foods with different morphologies of 0°–33° occlusion. All four studies followed the same protocols. In these studies, the strain gauges measured highest with 33° occlusion and lowest with 0° occlusion. The various authors concluded that the increased strain of 33° occlusion would be harmful to the alveolar bone. As it happened, the fact that the strain gauges registered high with this occlusion meant that the denture was working efficiently, directing valuable vertical stimulation to the alveolar ridge. The 0° occlusion diminished alveolar stimulation, dislodging the dentures laterally as the flattened teeth forced the patient to eat laterally.

It has been suggested that our evolutionary blueprint has programmed people for 0° occlusion and that all living humans were designed to eat with a flattened dentition. Neuberger, a dentist and anthropologist, warned the dental community in 1977 that deviation from this model may cause serious problems for patients and encouraged dentists to assist patients toward a flattened dentition, labeling this process as normal. It may be considered normal because it is common, but common isn’t necessarily good. It is poor speculation to declare that humans are predestined to have a flattened dentition when it is commonly known that many seniors maintain naturally sharp teeth.

**Dental compression syndrome**

McCollum & Stuart described a subtle pathology of function between the opposing teeth and movements of the mandible, declaring that the lack of understanding regarding this pathology has prevented dentistry from rendering substantial health services to its patients. That subtle pathology is called dental compression syndrome (DCS) (also known as parafunction or bruxism). DCS is defined as a total parafunctional activity that includes the grinding, gnashing, or clenching of teeth during the day and/or night. Capable of forces in excess of 500 psi, DCS can inflict compressive, tensile, shearing, and flexural forces on the dentition while simultaneously imposing unwanted force on the alveolar bone and the TMJ.

The goals in restorative dentistry are to treat the cases successfully and to keep the patient’s stomatognathic system healthy and comfortable until the next restorative case. In the author’s opinion, DCS is the biggest threat to those goals. DCS is a subconscious activity. Since many affected patients are unaware of the activity, the dentist must recognize the visual signs to address the problem. Obvious signs include a flattened dentition and hypertrophied masticatory muscles; in addition, there are certain deformations caused by clenching and grinding that affect the dentition, bone, and restorative materials and which many dentists misdiagnose or don’t understand. These deformations are not germane to each patient affected, as there are far too many variables, including the power and frequency of the compression, the genetic resistance of the alveolar bone, the patient’s gender, and his or her biologic strength.

DCS can be identified by four distinct types of deformations: a wedge-shaped noncarious lesion (NCL) found at the gingiva (Fig. 1); the inverted cupula, another NCL found at the tips of functional cusps (Fig. 2); exostosis (Fig. 3); and deformed restorative materials (Fig. 4).

**Gingival noncarious lesions**

Gingival NCLs are wedge-shaped and usually occur at the dentinoenamel junction (DEJ) (Fig. 5). This unique loss of tooth substance has been the subject of controversy among dentists for almost 100 years. The mystery is reduced if one understands the science of biomechanics—that is, the mechanical behavior of living materials and structure. Gingival NCLs that are multi-shaped examples of fatigue due to compression and tension are shown in Fig. 6-9.

Fatigue refers to changes in the properties of a material due to repeated applications of stress or strain; in this case, compression failure from DCS. Gordon described fatigue as one of the most insidious reasons why a structure loses...
its strength. If an object rebounds to its original shape after repeated compressions (such as a tennis ball), it is said to be elastic in nature; however, if an object exhibits residual defects after repeated compression, it is said to be plastic in nature. Biological structures such as teeth and bone are termed viscoelastic and are subject to deformation. Engineers refer to this type of fatigue as corrosion fatigue. Dentists don’t recognize corrosion fatigue because this is an engineering problem and the mechanisms of engineering are not emphasized in dental school, which often overlooks high math to focus more on chemistry.

It would behoove us to examine the design aspects of the dentition from an engineering point of view. In 1975, stress generated in a premolar as a result of occlusal forces was studied by using the finite element method, a mathematical technique well-suited to analyzing stress in teeth and dental restorations because it can closely simulate the geometrics, loads, and material in homogeneities in the system being studied. The analysis revealed that the DEJ was susceptible to cleavage or failure planes (Fig. 10). In this figure, a failure plane is apt to occur on the lingual face running through the DEJ well down into the root—the classic geometry of a gingival notch.

A year later, another team of engineers performed a similar study. They used the finite element method to demonstrate stress distribution and concluded that
the tensile forces in the gingival area are powerful enough to pull apart the enamel prisms. The authors concluded that these high stresses are likely responsible for the pain experienced by patients with cervically placed restorations. This study was conducted during the prebonding era, when dentists would mechanically lock in a restoration.

In a 1972 study, Hood demonstrated the unusual flexibility of teeth by using photoelasticity, placing teeth in a loading frame and applying pressure (Fig. 11). The frozen stress technique demonstrated an actual shortening of the tooth occlusally with an increase in its buccolingual diameter. The compression failure of an object occurs at its most vulnerable site, and teeth are most susceptible to failure in the gingival area. If the alveolar bone recedes, the failure site will also be lowered. Fig. 12 and 13 demonstrate defects that appear in tandem as the supporting bone atrophies, changing the fulcrum point. The only occlusal contact in Fig. 13 occurs on the incline plane, forcing the premolar to flex toward the lingual when the patient clenches. In orthopedics, these sites of destructive stress are termed vertical compression or wedge fractures.

Deformation of bone
Articles on bony protrusions (that is, torus palatinus and torus mandibularis) appeared in the literature as early as 1814 (Fig. 15-18). Although there is no consensus as to the etiology of bony protrusions,
many associate their occurrence with TMDs and masticatory hyperfunction.\textsuperscript{27,28} The negative ions generated from the compression of apatite crystals are responsible for the aggregates of new bone growth.

**Deformations of restorative materials**

Fatigue manifests easily in prostheses and restorative materials such as amalgam and acrylic. The wavy patterns (referred to by engineers as Luder lines or molecular slipbands) result from molecules in the alloy rearranging themselves following compressive strain. Fig. 19-22 demonstrate Luder lines in restorative materials. The deformations in the oral environment are important diagnostic tools, but their appearance does not mean that the patient is currently affected with DCS, as it may have occurred during a prior stressful period in his or her life.\textsuperscript{29}

**Guidelines**

There are two objectives when restoring a segment of a patient’s dentition: to design the new restoration correctly from an engineering point of view, and to ensure that the new restoration is in harmony with a healthy stomatognathic system. To that end, the new restoration should be designed to satisfy good engineering principles, with the occlusal contact at the tip of the functional cusp and touchless incline planes. As noted earlier, the stomatognathic system should be evaluated for signs of DCS and the remaining dentition should be evaluated to determine whether an equilibration might be indicated.

Management of DCS begins by recognizing the deformations of the dentition, bone, and restorative materials in the oral environment. In the author’s experience, many patients with \textdegree{0} occlusion have claimed to be quite comfortable because the damage had occurred in the past; to equilibrate their teeth would be disastrous. If the patient’s occlusion is uncomfortable, it should be determined whether equilibration is indicated.

In the author’s opinion, it is not necessary to use complicated instrumentation to accomplish equilibration. Instead, simply apply occlusal indicator wax on the occlusal surfaces of one arch, ask the patient to squeeze once, and analyze the areas of displaced wax. Ideal contacts are small and confined to the tips of the cusps and the central fossae. If the incline planes are touching, they should be reduced. If there is heavy contact in the central fossae, the opposing functional cusps should be sharpened. Lateral excursions should be checked for interferences. The teeth are never shortened. The equilibration reduces the stress on the teeth and allows greater freedom for the mandible; however, it doesn’t mean the patient won’t clench in moments of stress.

There is an exception to the rule that the original morphology of our teeth is superior to that of a flattened dentition. This isn’t meant to imply that all flat teeth should be equilibrated (sharpened). However, there should be a general understanding that preserving the original morphology of the dentition is superior to and more efficient than a flattened dentition. The stomatognathic system best serves the patient when it functions vertically and is free from clenching and grinding.
If clenching occurs during waking hours, patients must monitor themselves and make a conscious effort to keep their teeth apart (that is, keep the mandible at rest). If clenching and/or grinding occur while sleeping, the dentist must provide a comfortable guard.

The main reason for what the author refers to as occlusion confusion is that dentists have been accommodating the horizontal component of DCS instead of trying to prevent it. According to the Journal of Prosthetic Dentistry, anterior guidance (also known as mutually protected occlusion or mutually protected articulation) is defined as an occlusal scheme in which the posterior teeth prevent excessive contact of the anterior teeth in maximum intercuspation, and the anterior teeth disengage the posterior teeth in all mandibular excursions. The general understanding of anterior guidance is that there is some sort of mutual protection at work, although nothing could be further from the truth.

Is it possible that clenching the posterior teeth can prevent excessive contact on the anterior teeth? Not necessarily. A posterior tooth will be subject to more stress upon clenching than an anterior tooth simply because there is more surface contact upon closure; that is, stress is a result of lb/contact unit (stress = force/area). However, if the occlusal contact upon closure is equal for both molars and the lingual of the maxillary anterior teeth, the stress will be equal as well.

The author is aware of exceptions to the rule, but generally people do not grind their teeth during waking hours; rather, they clench. Since grinding in protrusion occurs only while sleeping, a comfortable nightguard would be appropriate. The idea of mutual protection is flawed in that it does not address the damage that the anterior teeth incur during parafunction. If this concept were credible, there would be little use for guards.

If patients are actively compressing their teeth while sleeping, then a guard is mandatory. It is normal for many patients to grind and clench while sleeping. The guard is not intended to stop such activities, but rather to provide an acrylic spacer that will absorb the compressive forces. The author’s preference is for the smaller anterior hard guards as they significantly reduce compression force. However, others recommend the larger guard that also covers the molars. They point out that the purpose of the larger guard is to support the TMJ, while this author believes that such guards only add more stress to the TMJ. Soft guards may encourage clenching and guards should only be worn while sleeping. Excessive use of a guard during waking hours can cause micromovement of the teeth.

**Rehabilitation and reconstruction**

A small percentage of dentists (estimated by the author to be less than 1%) limit their practices to patients who are severely compromised with problems related to occlusion. The mastication muscles are the benchmark for the neuromuscular concept of rehabilitation. The goal of neuromuscular rehabilitation is to establish a physiological terminal contact position (that is, the myocentric bite), using transcutaneous electric nerve stimulation (TENS). The incline planes of the teeth are then refined to ensure physiologic mandibular function. The masticatory system is stabilized by using a removable anatomical orthotic appliance that incorporates canine rise.

The gnathological approach is based on the position of the condyles in the glenoid fossae. During the reconstruction/rehabilitation of the stomatognathic system, the gnathologist seeks an optimum orthopedically stable joint position called centric relation, which refers to the condyles when they are in the anterior-superior position in the glenoid fossae, resting against the posterior slopes of the articular eminences, with the articular discs properly interposed. This position is considered to be the mandible’s most stable musculoskeletal position. Another goal of the gnathologist is stable holding contacts on all teeth to support the condyles in this centric relation, a position known as centric occlusion. The ultimate objective gnathological approach is to establish long-term occlusal stability: the ability for the dentition to accept heavy forces with minimal damage and function efficiently at the same time.

There are so many conflicting ideas, theories, and practical concepts related to the subject of restorations that a majority of dentists are unsure as to the right approach. One unfortunate effect of this confusion is that there is no consensus as to the best design for teeth. It is important that teeth retain their original morphology so they can work harmoniously and not distract the mandible from normal function. Regrettably, the role of the dentition in the function and dysfunction of the system has been obfuscated to the point that many believe there is no relationship at all. In 1995, Ramfjord & Ash reported that “a trend of thinking has developed that virtually denies any relationship between occlusal factors and disorders of the masticatory system.” Unfortunately, this attitude remains prevalent today.

An important step that could clarify some of the confusion would be to stop using the word occlusion in such a broad sense. Being more specific will simplify the thought or question. A 2008 article by Turp et al suggests that ideal occlusion is rarely found in real life, that the idea is open to personal interpretation, and that it is presumptuous to state nature’s intention for idealism. The author completely disagrees. We don’t need a clairvoyant to define ideal occlusion; we merely need a bioengineer with some knowledge of physiology. We also need to be specific about what is meant by the question. If we are concerned about the stomatognathic system, an ideal system—be it Class I, II, or III—would be one free from parafunction. The teeth in this system, be they crooked or straight, are naturally sharp, fit loosely with their antagonists, and confine occlusal contact to the tip of the cusp upon closure.

It is recognized that problems involving the TMJ can be the result of trauma, developmental deformities, or a disease process; however, in the author’s opinion, the vast majority of TMJ problems are the result of repetitive motion trauma from DCS. In the author’s 40-plus years of clinical practice, there has yet to be a single case of TMD that did not demonstrate one or more signs of parafunction. It would be appropriate to determine how parafunction relates to TMDs and determine whether the occlusal contacts are a contributing factor.

**Summary**

The confusion regarding the subject of occlusion has been a major distraction from dentistry’s focus on the far more important issue of parafunction. This
problem is unique in that it is part engineering and part psychological. For optimal results, dentists need to perform these three steps:

1. Design new restorations to satisfy accepted engineering principles (such as occlusal contact at the tip of the functional cusp and touch-free incline planes).
2. Evaluate the stomatognathic system itself for signs of DCS. If the patient has any parafunctional habits, the dentist must work with the patient to manage them properly.
3. Evaluate the remaining dentition to determine whether an equilibration is indicated.

Every five years, the Japanese sponsor an international consensus meeting on implantology. Respected authorities are invited to express their views on important issues, and a panel of judges determines a consensus for each issue for that point in time. Isn’t it about time we had one on occlusion? In the meantime, the author suggests that dentists keep teeth sharp and keep them apart.

**Author information**

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**References**

Exercise No. 324 TM Disorders (Occlusion) Subject Code 182

The 15 questions for this exercise are based on the article, Occlusion Confusion, on pages 69-75. This exercise was developed by Thomas C. Johnson, DMD, MAGD, in association with the General Dentistry Self-Instruction Committee.

Reading the article and successfully completing this exercise will enable you to:
• discuss the 3 factors contributing to occlusion confusion;
• learn the signs of parafunction/dysfunction; and
• understand the management of parafunction and an ideal occlusal scheme.

Answer form is on page 80. Answers for this exercise must be received by December 31, 2013.

1. Which of the following statements is true regarding occlusion?
   A. Most practitioners are aware of the basic concepts of occlusion.
   B. Most dental patients receive dental therapy based on occlusal principles.
   C. Occlusal principles permeate almost all of dentistry.
   D. Commonly taught occlusal techniques are practical in daily practice.

2. A valid definition of occlusion is a description of all the components of the stomatognathic system. The preferred definition of occlusion is the contact of the teeth of both jaws during those excursive movements of the mandible essential to the function of mastication.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

3. Which is true regarding the vertical function paradigm?
   A. There is 5-6 mm lateral parafUNCTION (bruxing).
   B. On closure, the mandible is guided by the glenoid fossae.
   C. The condyles seat in the anterior-superior portion of the fossae.
   D. The chewing movement is consistent and reproducible.

4. Which is true according to the horizontal function paradigm?
   A. It seeks to accommodate free passage for opposing dentition.
   B. Laterotrusive contacts are prevented, not eliminated.
   C. Lateral excursions are parafunctional movements.
   D. Anterior guidance involves shortening the anterior teeth.

5. According to gnathology, proper occlusal form is dictated by anterior guidance. Functional occlusion is defined as the touching of upper and lower teeth during mastication and degluttion.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

6. Which type of denture morphology has been shown to transfer higher vertical stimulation to the alveolar ridge?
   A. 20° occlusion
   B. Upper 10° occlusion
   C. 33° occlusion
   D. 0° (flat plane) occlusion

7. The signs of DCS include all of the following except one. Which is the exception?
   A. Deformation of restorative materials
   B. Atrophy of the alveolar bone supporting teeth
   C. Hypertrophy of the muscles of mastication
   D. Flattening of the dentition

8. The characteristics of the wedge-shaped noncarious lesions (NCLs) include all of the following except one. Which is the exception?
   A. Position will change as bone support is lost
   B. Site-specific with a dull matte appearance
   C. Variously shaped and located depending on the vectors of forces
   D. Explained by biomechanical stress studies

9. Evidence supporting parafunction as a cause of wedge-shaped NCLs include all of the following except one. Which is the exception?
   A. Photodensitometry studies
   B. Stress analysis
   C. Piezoelectric effect
   D. Compression fatigue

10. Which is the most common compression NCL?
    A. Luders’ lines
    B. Wedge-shaped gingival lesions
    C. Cracked fillings
    D. Inverted cupola

11. The inverted cupola is most commonly found on permanent second molars. This is due to the higher incidence of occlusal prematurities on these teeth.
    A. Both statements are true.
    B. The first statement is true; the second is false.
    C. The first statement is false; the second is true.
    D. Both statements are false.

12. When planning an occlusal equilibration, the author’s initial analysis involves use of
    A. mounted models and trial equilibration.
    B. occlusal indicator wax.
    C. multiple colors of Mylar articulating strips.
    D. Mylar articulating strips and 8-µm shim stock.

13. The author’s approach to the treatment of parafunction advocates which of the following?
    A. LVJ neuromuscular
    B. Pankey centric relation equals centric occlusion scheme
    C. Okeson orthopedically stable joint position
    D. Prevention of DCS

14. The vast majority of temporomandibular joint dysfunction problems are a result of
    A. repetitive motion trauma from DCS.
    B. arthritic disease processes.
    C. developmental deformities.
    D. trauma.

15. Teeth in an ideal occlusion have all of the following characteristics except one. Which is the exception?
    A. Mutually protected scheme
    B. Fit loosely with their antagonists
    C. Are naturally sharp
    D. Occlusal contact confined to the tip of the cusp
Asymptomatic swelling in the floor of the mouth

A 63-year-old male was referred to a specialized oral medicine clinic for assessment of an asymptomatic swelling in the floor of the mouth. The swelling was noticed for at least 6 months and had progressively enlarged; no other symptoms were reported. The patient reported a history of hypertension (controlled by atenolol) and was a nonsmoker. Clinical examination showed a dome-shaped swelling that was firm to palpation, approximately 2 cm in maximum dimension, covered by normal mucosa of bluish color in the right floor of the mouth (Fig. 1). Imaging studies, including ultrasonography and computed tomography, confirmed the presence of a hypodense lesion, 1.9 cm in diameter, without involvement of the submandibular gland or its duct, and without evidence of a salivary stone (Fig. 2). The lesion was surgically removed and submitted for histopathological examination (Fig. 3).

Which of the following is the most probable diagnosis?
A. Sialolithiasis  
B. Salivary duct cyst (ranula)  
C. Cystadenoma  
D. Chronic sialadenitis  
E. Lipoma

Diagnosis is on page 78.

Asymptomatic nodule in the posterior tongue

A 42-year-old female visited a specialized oral medicine clinic for evaluation of an asymptomatic swelling in the right tongue of unknown duration. The patient was a smoker (approximately 1 pack per day); her medical history was noncontributory. Clinical examination revealed a nodule of soft consistency covered by intact pinkish-yellowish mucosa with distinct surface capillaries in the right posterior lateral border of the tongue (Fig. 1). The rest of the oral mucosa was within normal limits. An excisional biopsy was performed and histopathological examination showed dense lymphoid tissue with germinal center formation surrounding an epithelial-lined cavity (Fig. 2).

Which of the following is the most likely diagnosis?
A. Reactive lymphadenitis  
B. Lipoma  
C. Oral lymphoepithelial cyst  
D. Lymphoepithelial carcinoma  
E. Branchial cleft cyst

Diagnosis is on page 78.
### Asymptomatic swelling in the floor of the mouth

**Diagnosis:**

**B. Salivary duct cyst (ranula)**

Unlike mucoceles, which are caused by mucin extravasation, salivary duct cysts represent true cysts arising in minor or major salivary glands, most commonly within the parotid. When a salivary duct cyst occurs in the floor of the mouth, it is frequently called a ranula, although some authors prefer to reserve the use of this term only for lesions caused by mucin spillage, usually derived from the body of the adjacent sublingual gland, the submandibular duct, or from minor salivary glands situated in the floor of the mouth.

Salivary duct cysts develop in adults and are usually asymptomatic. The floor of the mouth is a common location for the development of salivary duct cysts, which appear clinically similar to ranulas attributed to spillage of mucin, i.e., dome-shaped nodular swellings of soft, fluctuant, or, less often, firm consistency and bluish or pinkish color. If they acquire a large size, they may cause elevation of the tongue. The plunging ranula is a subtype and manifests as a soft swelling in the neck owing to extension of the spilled mucin below the mylohyoid muscle.

Histopathological examination of a salivary duct cyst shows a dilated cystic space lined by thin squamous, cuboidal, or columnar epithelium, and surrounded by a fibrous wall. In contrast, ranulas typically lack an epithelial lining and present as an accumulation of mucin surrounded by a granulation tissue wall.

Imaging studies may provide useful information regarding the exact size and location of a ranula, its association with the adjacent major salivary glands, and the potential presence of a sialolith or a mass obstructing a salivary duct. This information is useful during the surgical intervention, which, based on the clinical, imaging, and intraoperative findings, may entail marsupialization, dissection, and removal of the lesion alone and/or removal of the offending major salivary gland. The likelihood of recurrence varies according to the surgical procedure and appears higher for lesions managed by marsupialization.

### Bibliography


### Asymptomatic nodule in the posterior tongue

**Diagnosis:**

**C. Oral lymphoepithelial cyst**

The oral lymphoepithelial cyst is an uncommon developmental soft tissue cyst of the oral mucosa. It can affect patients of any age, more often young adults, and does not show gender predilection.

As implied by its name, the oral lymphoepithelial cyst is composed of an epithelium-lined cystic cavity surrounded by abundant lymphoid tissue. It develops in areas harboring oral lymphoid tissue, such as the floor of the mouth (accounting for about half of the cases), ventral surface and posterolateral border of the tongue (up to 40% of cases), and around the Waldeyer ring. Various theories of pathogenesis have been proposed, such as the entrapment of epithelial elements within oral lymphoid tissue aggregates during embryogenesis or the obstruction of normal epithelial invaginations into the underlying oral lymphoid tissue. Subsequent epithelial proliferation results in the formation of a cystic mass.

The branchial cleft cyst can be considered to be the counterpart of the oral lymphoepithelial cyst in a lateral cervical location. In addition, lymphoepithelial cysts of the parotid glands have been seen with increased frequency among HIV-positive patients.

The oral lymphoepithelial cyst usually presents as a <1cm submucosal nodule of soft or rubbery consistency covered by intact mucosa of whitish, yellowish, or pinkish color. It is asymptomatic unless secondarily traumatized. Microscopic examination reveals a cystic cavity, sometimes filled with keratin, lined by stratified squamous epithelium that is often parakeratinized. The cyst wall is occupied by dense lymphoid tissue with frequent germinal center formations.

Conservative surgical removal is considered to be the treatment of choice and recurrences are not expected.

### Bibliography

**Self-Instruction**

**Exercise No. 297**
January/February 2012, p. 25
1. B  
2. C  
3. A  
4. D  
5. C  
6. D  
7. A  
8. B  
9. B  
10. C  
11. B  
12. B  
13. A  
14. B  
15. D  

**Exercise No. 298**
January/February 2012, p. 44
1. A  
2. B  
3. C  
4. B  
5. A  
6. B  
7. D  
8. A  
9. B  
10. D  
11. A  
12. C  
13. A  
14. C  
15. D  

**Exercise No. 299**
January/February 2012, p. 56
1. B  
2. C  
3. A  
4. B  
5. D  
6. C  
7. A  
8. B  
9. C  
10. A  
11. A  
12. B  
13. B  
14. B  
15. D  

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Correct □ Incorrect □ Incorrect

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EVALUATION Please respond to the statements below, using the following scale: 1 Poor; 2 Below average; 3 Average; 4 Above average; 5 Excellent

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 Deadline for submission of answers to Exercises 321-324 is December 31, 2013.
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Five-minute nutrition workup for children in dental practice

S.M. Hashim Nainar, BDS, MDSc

Overweight and obesity are significant health concerns for children in the United States; however, dentists can provide a nutrition workup for their patients as part of the effort to address this issue. A child’s weight status can be assessed after measuring the child’s height and weight without the need to compute body mass index. At that point, 5 nutrition- and health-related items can be discussed with patients and parents. Both can be accomplished in just a few minutes. Evidence-based nutrition guidance can be integrated into contemporary nutrition counseling for caries prevention in a seamless manner without negative connotations regarding a patient’s weight.

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Accepted: May 7, 2012

In a 2011 article, Lamster & Eaves proposed a dental practice model for the 21st century that would reconceptualize and expand the scope of practice to include primary health care activities, such as screening for diabetes mellitus and obesity interventions.1 According to the literature, chairside testing of blood glucose to determine the presence of diabetes mellitus has been well-received both by patients and by practitioners; in addition, weight screening strategies for children and adults in the dental office also have been described in the literature.2-4

Screening children for overweight/obesity presents unique challenges compared to screening adults. As with adults, the body mass index (BMI) must be computed; however, age and gender-specific BMI percentile data also must be consulted to determine a child’s weight status.3-4 These additional steps may explain why only 52% of U.S. pediatricians and 45% of family physicians bother to routinely assess BMI in children.5,6

The importance of screening children for overweight/obesity is underscored by data from the National Health and Nutrition Examination Survey (NHANES) 2009-2010, which reported that 33% of U.S. school-age children (aged 6-19 years) are overweight; of those, 18% are reported to be obese.7 Increased body weight in children leads to such comorbidities as type 2 diabetes mellitus, nonalcoholic fatty liver disease, and cardiovascular disease.8 According to Singh et al, overweight/obese children also are more likely to become overweight adults.9 Of the lifelong implications of unhealthy weight in childhood, Olshansky et al reports, “the youth of today may, on average, live less healthy and possibly even shorter lives than their parents.”10 This proposition provides an even greater motivation for dentists to incorporate obesity counseling into practice as part of their “desire to have an impact on patients’ general health.”11

According to a 2010 survey by Curran et al, dentists “are in an ideal position to recognize patients at risk of developing weight problems” as they already offer nutrition counseling to children to prevent dental caries.12 A 2009 article by Tavares & Chomitz described an intervention program for dental practices designed to help children maintain a healthy weight.3 The protocol for their pilot study was based upon motivational interviewing and was directed toward all 139 of the children involved, regardless of their weight status. The intervention included measuring the child’s height and weight, assessing BMI, and providing “recommendations for healthy behavior modifications.”9 Dental hygienists who provided the intervention were able to complete all of their duties for each preventive dental visit (including the intervention) within an average of 40 minutes. Caregivers responded positively to the intervention with 96% making better food choices for their children, 81% reporting less television/video time, 72% reporting more exercise, and 67% reporting that their child ate breakfast more often.3

As a recent survey of U.S. dentists and their attitudes toward obesity prevention/intervention, more than 50% of the respondents expressed concern about appearing judgmental or offending patients and their parents.12 The survey also found that 51% of the respondents were interested in offering obesity-related services, although some reported a lack of knowledge regarding the topic.12

The current authors sought to provide a pragmatic and concise evidence-based nutrition workup—based in part on the recommendation of Tavares’ & Chomitz’s recommended behavioral strategies for healthy weight in children—that could be utilized in the dental office.3

Assessment of weight status in children

After the child’s height and weight have been measured, his or her weight status can be assessed using recently published gender-specific screening tables based on growth charts from the Centers for Disease Control and Prevention.13 These simplified overweight/obesity screening tables eliminate the need to compute individual BMI or determine BMI percentiles and simply indicate whether the child has normal weight or is overweight/obese.13 Based on the assessment, parents and patients can then be informed as to whether the child has healthy weight.

Counseling children for healthy weight

In addition to nutrition counseling for the prevention of dental caries, the following five counseling items can be provided to all children, regardless of their weight status.14

Do not skip breakfast

Data from NHANES (1999-2006) has shown that 20% of children ages 9-13 and 32% of those ages 14-18 skipped breakfast.15 Those who skipped
breakfast had higher BMI scores and a greater prevalence of obesity.15

**Limit/avoid sugar-sweetened beverage consumption**
A systematic four-decade literature review (1966-2005) found an association between increased consumption of sugar-sweetened beverages (particularly soda) and weight gain and obesity among children and adolescents.16

**Be physically active for at least 1 hour per day**
Data from NHANES (2003-2004 and 2005-2006) concerning children ages 6-17 reported that “weight status was inversely related to activity.”17 The American Academy of Pediatrics advises that children and adolescents “be physically active for at least 60 minutes per day,” preferably participating in activity that is “unstructured and fun” to ensure good compliance.18

**Limit screen time to less than 2 hours per day**
Data from NHANES (1988-1994) regarding 8- to 16-year-old children has shown that obesity was lowest among those who watched television for 1 hour or less per day and was highest among those children who watched television for 4 hours or more per day.19 The American Academy of Pediatrics recommends that children limit screen time to less than 2 hours per day with an “electronic media-free environment in children’s rooms.”20

**Get adequate sleep**
While the amount of sleep per day considered to be sufficient differs for each child, data from the U.S. Panel Survey of Income Dynamics Child Development Supplements indicate 12-14 hours for children ages 1-3, 11-13 hours for children ages 3-5, 10-11 hours for children ages 5-10, and 8.5-9.5 hours for adolescents.21 Insufficient sleep has been associated with increased weight.21

These 5 counseling items can provide positive guidance for children with unhealthy weight while reinforcing good habits in children with normal weight.

**Conclusion**
The nutrition workup described can be integrated into contemporary dental practice to promote healthy living. The 5 counseling items allow dentists to address the issue of overweight/obesity without concern for overtly targeting the child’s weight. This perception is important as Curran et al reported that U.S. dentists have expressed concern that causing offense or appearing judgmental of the patient or the parent is the most common barrier to providing obesity-related interventions.12

Assessing weight status in children and providing the select counseling described in the present nutrition workup can presumably be accomplished in a few minutes. Tavares & Chomitz found that as part of a regular preventive dental visit, the healthy weight intervention detailed in their 2009 article (including computation of individual BMI, determination of BMI percentile score, and motivational interviewing on select nutrition topics) could be accomplished in less than 40 minutes.9 Therefore, it should be possible to integrate the nutrition workup described in the present study into dental checkups in a timely and efficient manner.

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**References**
Influence of polishing procedures on the surface roughness of dental ceramics made by different techniques

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Geraldo Henrique Leao Lombardo, DDS, MSc • Fernanda Campos, DDS • Hugo Ramalho Sarmento, DDS
Rodrigo Othavio Assuncao Souza, DDS, MSc, PhD

The aim of this study was to evaluate the influence of 2 different surface polishing procedures—glazing (GZ) and manual polishing (MP)—on the roughness of ceramics processed by computer-aided design/computer-aided manufacturing (CAD/CAM) and conventional systems (stratification technique). Eighty ceramic discs (diameter: 8 mm, thickness: 1 mm) were prepared and divided among 8 groups (n = 10) according to the type of ceramic disc and polishing method: 4 GZ and 4 MP. Specimens were glazed according to each manufacturer’s recommendations. Two silicone polishing points were used on the ceramic surface for manual polishing. Roughness was measured using a surface roughness tester. The roughness measurements were made along a distance of 2 mm on the sample surface and the speed of reading was 0.1 mm/s. Three measurements were taken for each sample. The data (µm) were statistically analyzed using analysis of variance (ANOVA) and Tukey’s test (α = 0.05). Qualitative analysis was performed using scanning electron microscopy (SEM). The mean (± SD) roughness values obtained for GZ were: 1.1 ± 0.40 µm; 1.0 ± 0.31 µm; 1.6 ± 0.31 µm; and 2.2 ± 0.73 µm. For MP, the mean values were: 0.66 ± 0.13 µm; 0.43 ± 0.14 µm; 1.6 ± 0.55 µm; and 2.0 ± 0.63 µm. The mean roughness values were significantly affected by the ceramic type (P = 0.0001) and polishing technique (P = 0.0047). The SEM images confirmed the roughness data. The manually polished glass CAD/CAM ceramics promoted lower surface roughness than did the glazed feldsparic dental ceramics.

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The increased development of ceramic materials and number of patients searching for esthetic oral rehabilitation, combined with some of the limitations of metallic restorations such as toxicity, allergenic potential, and esthetics, have made ceramics one of the most commonly employed materials in restorative dentistry.1–4 Many in vitro and in vivo studies have been performed to improve porcelain restorations to satisfy the cosmetic, mechanical, and physical requirements of a restorative material.5

CAD/CAM systems have been used in dentistry since their development by Duret in the 1970s.6 Revolutionizing dentistry, several ceramic systems were developed based on computation science to enhance laboratory steps and clinical results of ceramic restorations. Using prefabricated high-quality, homogenous ceramic blocks, these CAD/CAM systems are different from the conventional feldspathic ceramic powder, and they result in a combination of biocompatibility, absence of metal, natural esthetics, durability, and a low rate of fractures.7,8

Among them, the CEREC system (Ceramic REConstruction) is one of the most popular in the world.9

Regardless of the technique used, glazed ceramic restorations need some adjustments in several clinical situations, mainly with the occlusal and interproximal areas, even when a new glazing procedure will not be performed again.10,11 These adjustments have the potential of increasing the ceramic’s roughness and, thus, the potential of wearing down the antagonist teeth and promoting excessive dental biofilm.12–14 Several studies have demonstrated that dental biofilm is formed in larger amounts and more quickly on rough surfaces.15 Moreover, the microbial colonization on oral surfaces and on restorative materials is considered an important factor that contributes to the development of caries and periodontal disease.15 In ceramic adjustments, the roughness must be minimized using intraoral polishing techniques to achieve an acceptable smoothness.3

According to Al-Wahadni & Martin, glazed ceramic accumulates the least amount of dental biofilm and also allows it to be easily removed.3 On the other hand, according to Scotti et al, ceramic surfaces that are polished mechanically with a silex rubber wheel accumulate less biofilm than glazed ceramic.16 According to Bottino et al, efficient manual mechanical polishing should use diamond burs on ceramic surfaces, followed by the use of abrasive rubber tips and felt discs with diamond paste.1

However, mechanical polishing can be influenced by the ceramic microstructure and production techniques; therefore, glazing procedures have traditionally been recommended.17 In the case of clinical ceramic adjustments, additional clinical steps are necessary.

Thus, the aim of this study was to evaluate the influence of 2 different surface polishing procedures—glazing (GZ) and manual polishing (MP)—on the roughness of ceramics processed by CAD/CAM and stratification technique. The hypothesis was that the roughness is influenced by both the surface polishing procedure and by the ceramic type.

Materials and methods

The brand names, types, and manufacturers of the materials used in this study are presented in Table 1.

Fabrication of the samples

Twenty discs (diameter: 8 mm, thickness: 1 mm) were prepared for each ceramic type. To fabricate the CAD/CAM samples—ProCAD (Ivoclar Vivadent AG) and Vita...
Mark II (VITA Zahnfabrik)—the CEREC inLab system (Sirona Dental Systems, Inc.) and CEREC 3D program (version 2.9x, Sirona Dental Systems, Inc.) were used. Each disc image (8 mm x 1 mm) was sent to the computer-aided manufacturing unit and 40 discs where milled. A new set of cylindrical milling burs (diameter: 1.6 mm; 1.2 mm/step), was used for each group.

To fabricate the conventional ceramic samples—VM7 (VITA Zahnfabrik) and IPS e.max Ceram (Ivoclar Vivadent AG), a metallic device (diameter: 8 mm, thickness: 1 mm) was used to standardize the sample size. The dentin ceramic powder and liquid were mixed, homogenized, and inserted into the metallic device. After removal from the assembly, the ceramics were fired in their respective ovens: For the VM7, a Vacumat 40 (VITA Zahnfabrik) was used, and for the IPS e.max Ceram, a Programat P500 (Ivoclar Vivadent AG) was used. Due to shrinkage, a second layer was applied and the specimens were submitted to a final firing. The firing cycles of the dental ceramics and glazes are presented in Table 2.

**Polishing procedures**

One surface of each ceramic disc was then leveled and polished in a polishing machine (PSK-2V, ERIOS Equipamentos) using silicon-carbide papers in sequence (600-, 800- and 1200-grit sandpaper, 3M ESPE) under water-cooling.

The ceramic discs were then divided into 8 groups (n = 10) according to type of ceramic disc (4 levels: Vita Mark II, ProCAD, IPS e.max Ceram, and VM7) and polishing procedures (2 levels: GZ and MP). The glazing procedures were carried out according to each manufacturer’s recommendations. For manual polishing, 2-step silicone rubber wheel points were used on the ceramic surface (Exa-Cerapol, Edenta AG) for 10 seconds each step, with a mean speed of 400 rpm and manual pressure. All procedures were performed by the same operator, in order to standardize the pressure during the polishing procedures.

**Roughness test**

A portable surface roughness tester (Hommel tester T200, Hommel-Etamic GmbH) was used to measure the mean roughness of the polished surfaces. The roughness measurements were made on three different areas (central line and above and below the central line) on each sample surface in order to take a surface profile (peaks and inverted valleys) and determine the arithmetic average values of the departures from profile from the center line (Ra values).

The test was performed by the same operator on each polished surface and was performed three times for each sample (scanned length: 2 mm, speed of reading: 0.1 mm/s).

**Morphology analysis**

Morphology and chemical analysis was performed on a sandblasted surface of a sample from each of the 8 groups using a scanning electron microscope (JEOL-JSM-5400, JEOL Ltd.) equipped with an energy dispersive X-ray and the INCA Energy program (Oxford Instruments). These samples were initially fixed on an aluminum support with double-sided carbon adhesive tape and after were sputter-coated with a gold-palladium alloy in a sputter coater (Polaron SC7620, Quorum Technologies Ltd.) (time: 130 s; current: 10-15 mA; vacuum: 130 mTorr; sputter coating rate: 3.5 nm/min, approximate layer of Pd-Au of 80 Å) for SEM analysis with 5000X and 1500X magnifications.

**Statistical analysis**

Statistical analysis was performed using Statistix for Windows (version 8.0, Analytical Software). The mean roughness (μm) of each group was analyzed using two-way ANOVA and Tukey’s test, with the variables of ceramic type and polishing method. P values < 0.05 were considered statistically significant in all tests.

**Results**

The results of two-way ANOVA for the experimental conditions are presented in Table 3. The mean of the roughness values were significantly affected by the ceramic types (P = 0.0001 < 0.05; CAD/CAM: 0.8 μm; conventional feldspathic: 1.85 μm) and polishing technique (P = 0.0047 < 0.05; GZ: 1.47 μm; MP: 1.18

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**Table 1. Brand names, types, and manufacturers of materials used.**

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<tr>
<th>Brand name</th>
<th>Type</th>
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<td>ProCAD</td>
<td>Glass ceramic block</td>
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<td>Vita Mark II</td>
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<td>VITA Zahnfabrik, Bad Sackingen, Germany</td>
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<td>Vita Akzent 25</td>
<td>Glaze</td>
<td>VITA Zahnfabrik, Bad Sackingen, Germany</td>
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<td>IPS e.max Ceram Glaze</td>
<td>Silicone ceramic polisher points</td>
<td>Ivoclar Vivadent AG, Schaan, Leichtenstein</td>
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<td>Exa-Cerapol</td>
<td>(gray and pink)</td>
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**Table 2. Firing procedures of the dental ceramics and glazes.**

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The interaction between the ceramic types and polishing technique factors was not statistically significant (\(P = 0.1706\)).

Mean (± SD) roughness values and the homogeneous groups are presented in Table 4. The results of Tukey’s multiple comparison test demonstrated that, when the factor of polishing technique was analyzed for each ceramic, the roughness values after manual polishing were statistically lower when compared to glazing. Moreover, when the factor ceramic type was analyzed, the conventional ceramics (VM7 and IPS e.max Ceram) presented higher roughness values when compared to the CAD/CAM ceramics (ProCad and Vita Mark II) (Table 4 and Chart).

The Vita Mark II and ProCad presented better roughness values, mainly after manual polishing (0.66 μm and 0.43 μm, respectively). The VM7 ceramic showed significantly worse roughness values after both glazing (2.2 ± 0.73) and manual polishing (2.0 ± 0.63) than did the other ceramics. However, these values were statistically similar to E-max Ceram, according to the Tukey’s test (Table 4).

**SEM analyses**

The SEM analyses of the ceramic surfaces revealed that the specimens submitted to manual polishing with silicone points (regardless of the ceramic used) presented similar morphology than when compared to the glazed ceramics (Figure). However, small pores could be found in the glazed samples when analyzed with higher magnifications, suggesting that this procedure can promote higher roughness values when compared to polished surfaces.

**Discussion**

Several studies have compared glazing to manual polishing techniques.\(^3^{,}18^{,}20\) A smooth surface is especially desirable in order to reduce the rate of plaque biofilm accumulation, decrease wear of the opposing dentition, and provide a shiny appearance.\(^12^{,}13^{,}18\) Moreover, smooth ceramic surfaces may improve the overall strength of the ceramic restoration.\(^21\)

Surface roughness refers to the irregularities on a specific surface. In the current study, Ra values were obtained using a surface roughness tester and measured in micrometers (μm), as with other studies.\(^3^{,}20^{,}21^{,}24\) However, other methods were used in previous studies to measure surface roughness, including a profilometer, atomic force microscopy, and confocal laser microscopy.\(^12^{,}18^{,}19^{,}23^{,}32\)

In the current study, CAD/CAM ceramics (Mark II and ProCad) presented the lowest roughness values, regardless of the polishing technique used. This can be explained by the material’s characteristics, such as the homogeneity and high quality of the components in the ceramic material. These results confirm findings previously reported by Sarikaya & Guler, who compared the roughness of conventional and machinable ceramics polished...
by different techniques. According to that study, ceramics manufactured by the same processing method showed similar roughness values after polishing or manual glazing. This can be explained by the similarities in the chemical composition (Table 1) of the materials that use the same processing technique, which causes them to behave similarly with the polishing methods employed.

In this study, the roughness values for glazed specimens were statistically higher when compared to the manually machine polished specimens (Table 4). Studies have shown that polishing methods can result in a final ceramic surface that has a similar or better roughness than glazed-fired ceramic surfaces. Other studies presented opposing data. However, Sof-Lex discs are difficult to use on molars or occlusal surfaces, which limits their use. Thus, mechanical polishing of ceramic restorations using rubber wheels can be clinically indicated, especially in areas with limited access such as with the occlusal surface of posterior teeth.

Based on the results obtained in this study, mechanical polishing can be used after adjustments made to CAD/CAM or conventional ceramic surfaces, promoting lower roughness values compared to those provided by glazing. However, other CAD/CAM systems might respond differently to the testing scenario. Further studies should be developed in order to define the most appropriate mechanical polishing for dental ceramics. Additionally, it is important to conduct long-term in vitro and clinical studies to confirm the current data.

Conclusion

The aim of this study was to evaluate the influence of 2 different surface polishing procedures on the roughness of ceramics processed by CAD/CAM and stratification technique. The hypothesis the authors proposed in the introduction was that the roughness is influenced by both the surface polishing procedure and by the ceramic type. This hypothesis was accepted. Within the limitations of the present study, glass CAD/CAM ceramics associated with manual polishing promoted lower surface roughness values when compared to glazed feldspathic ceramics.

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41.7174.453.53, www.edenta.com
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49.0.7761.56.20, www.vita-zahnfabrik.com
3M ESPE, St. Paul, MN
888.364.3577, solutions.3M.com
Vascular leiomyoma is a benign tumor arising from smooth muscle that is commonly found in the uterus (95%), skin (3%), and gastrointestinal tract (1.5%), and occurs rarely in the head and neck (less than 1% of cases).¹

According to Silveira et al, clinical features of vascular leiomyomas found in the mouth include the following: small nodules with a smooth submucosa; rarely, epithelium overlying an ulcer (although in some cases, there is histological evidence of ulceration); slow growth; variable size (although rarely larger than 5 cm); color variation due to vascularization and depth in the tissues; asymptomatic; and in a few cases, there were reports of pain.²

Histologically, the neoplasm is characterized by bundles of smooth muscle fibers arranged in a standard interlaced, sometimes storiform, pattern intermingled with connective tissue in variable quantity. With regard to its morphology, the World Health Organization calls for subdivision into three variants: solid, vascular (vascular leiomyoma), and epithelioid. The most common histological subtype in the oral cavity is the vascular subtype. Vascular leiomyoma has a frequency of 74% and is characterized by a well-defined proliferation of mesenchymal cells with tapered eosinophilic cytoplasm and elongated nuclei basophils showing conical endings.³

The literature, with regard to clinical and pathological findings, has demonstrated that there are few differences in behavior between immuno-enzymes and subcellular entities. The greatest difficulty in histological diagnosis of this entity is the similarity in morphology with other malignancies, particularly of neural or fibroblastic lineage. Special stains with proven diagnostic value are often not successful in demonstrating myofibrils. This has led authors to use other techniques to elucidate the diagnosis, such as transmission electron microscopy and immunohistochemistry.⁴ Other authors believe leiomyomas arise from the remnants of embryonic tissue found in such areas as the lingual duct or taste buds.⁵

Some authors believe that men and women are affected in equal proportion; however, there is considerable controversy on this point because other researchers have reported a 2:1 predilection for females, while others have shown that men outnumber women at a ratio of 2:1.⁶

There are also discrepancies in the literature as to the site of predilection for oral cancer; authors such as Wertheimer-Hatch et al have reported that the vascular leiomyoma is most commonly located on the tongue, followed by the palate, cheek mucosa, and lower lip.⁷ However, Savage et al reviewed the literature and argued that the sites most affected are the lips, followed by the palate, tongue, and cheek mucosa.⁸ Additionally, Baden et al found vascular leiomyomas more commonly on the lips, followed by the tongue, cheek, and palate.⁹

The differential diagnosis of vascular leiomyoma of the oral cavity should be done with other tumors that occur in this region and is based mainly on histopathological examination. For diagnosis, a lesion that serves as a comparison to leiomyoma in the oral cavity is the fibroma, which is the most frequent oral fibrous lesion and is considered by some authors to be a non-neoplastic benign lesion (that is an increase of focal reactive oral mucosa).¹⁰

Distinguishing between leiomyoma and leiomyosarcoma of low-grade malignancy can be tricky. The morphological differentiation is based on the degree of cellular pleomorphism, necrosis, hyperchromatism, and nuclear atypia, especially in the presence of mitosis.¹⁰ Of note, 5 or more mitoses per field should also be observed.¹¹ The spindle cell lesions have morphological differences, which can be explained by their histogenesis from the mesenchymal stem cells during embryogenesis. Like fibroblasts, leiomyocytes are spindle cells, and making the distinction between these cells can be difficult.¹²

Neoplasms of neural origin, such as neurilemmomas, neurofibromas and granular cell tumors, and lesions usually confined to reports of occurrence in the literature, must be researched and included in the differential diagnosis because of their histopathology.¹³ Some symptoms are due to local growth; difficulty swallowing, toothache, loose teeth, or pain in the temporomandibular joint have also been reported.¹⁴ Shortness of breath can also be caused by large tumors. Pain at the site is suspected to be attributable to ischemia and tumor vessel contraction due to nerve irritation by the tumor.¹⁵

Treatment of these tumors is based on local resection with no reports of recurrence after total excision. In 2001, Bloom et al reported a case of recurrence after spontaneous extrusion of the tumor, but the patient was retreated and no recurrence occurred after surgical excision.¹⁶ This event demonstrates the potential recurrence after an incomplete removal and the need for complete,
excision to ensure a definitive treatment. The patient was free of disease 1 year after complete surgical excision. The first case of leiomyoma in the oral cavity was reported by Blanc et al in 1984, but from 1984 to 1996, only 139 cases of leiomyoma of the oral cavity were reported in the literature. The aim of this study was to examine a 2005 case of vascular leiomyoma located in the oral mucosa of the oral cavity.

Case report
In 2005, a 25-year-old female was sent to the oral and maxillofacial department of St. Joseph Hospital in Criciuma, Santa Catarina, Brazil, with unilateral facial asymmetry on the left side (Fig. 1). The intra-oral lesion showed submucosal consistent palpation with a color similar to the mucosa, of approximately 4 to 5 cm in diameter, that was located in the oral mucosa on the left. A clinical hypothesis of dentoalveolar abscess was made.

An ultrasound of the patient’s face was performed and an oval lesion was observed in the subcutaneous tissue of the left hemiface. The lesion was hypoechoic relative to fat with well-defined borders. In ultrasonography, it was observed that the lesion measured 5.4 cm at its greatest diameter (antero-posterior) and 4.0 cm at its largest diameter side. It was not possible to measure the craniocaudal length due to overlap with the zygomatic arch. It was given a possible diagnosis of parotid pleomorphic adenoma originating from the accessory salivary gland.

The patient underwent surgery that included an excisional biopsy under general anesthesia with orotracheal intubation. A superficial incision was made on the affected area, and after displacing the soft tissues of the oral mucosa, as well as the nerves and vessels, the lesion was dissected and removed. An internal suture with absorbable thread and external suture with silk thread were made. The lesion material was then sent for pathological examination (Fig. 2-4).

Macroscopically, it was observed to be a 6.5 x 4 mm, 76 g nodule with an elastic-firm consistency and smooth surface with whitish parenchyma with fibrous bands and areas of a myxoid aspect (Fig. 5 and 6). Microscopically, it was diagnosed as leiomyoma with myxoid areas and no malignancy (Fig. 7 and 8). After complete resection was achieved, follow-up examinations were done at 2, 5, and 12 months (Fig. 9-11). A recurrence could not be detected.

Discussion
One factor that makes vascular leiomyomas in the oral cavity rare is that there is little smooth muscle in the mouth. The formation of fibroids is possibly due to the fact that the oral cavity is rich in blood vessels and, therefore, it has been proposed that the endothelium, the smooth muscle...
medial layer of those blood vessels, and smooth muscles of the excretory duct of the salivary glands, are the source of vascular leiomyoma of the oral cavity. 3

This lesion type accounts for 5% of all fibrous proliferation that undergoes biopsy. It is usually observed in young patients and is more frequent in the first 3 decades of life, presenting as asymptomatic lesions or papillary, lobulated, or pedunculated tumors measuring less than 1 cm in diameter and mainly affecting the lower gum and the apex and lateral border of the tongue. 11 The literature also suggests that there is a slight predilection for females to present with these lesions. 6

The diagnosis of fibroids is relatively difficult to establish due to the similarity of these lesions with other spindle cell tumors. The differential diagnosis should include other mesenchymal tumors (such as neurofibroma, lipoma, etc) and salivary gland neoplasms (such as mucocele, pleomorphic adenoma, etc). 6

The neoplastic nature of leiomyomas has been questioned by some authors who discuss the possibility that vascular leiomyomas represent a final stage in the progressive maturation of a hemangiomata and are therefore hamartomatous lesions. 2

Wide surgical resection is the only treatment reported in the literature with good results. The recurrence rate is very low if complete resection is achieved. 13

The study of rare or unusual lesions is very important for the clinical diagnosis of vascular leiomyoma in the oral cavity. These studies allow clinicians to collect new information about the biological behavior and prognosis of these lesions. For more meaningful clinical use, future studies and case reports should be done.

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**References**


Peripheral giant cell granuloma: a case report

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Peripheral giant cell granuloma is a rare exophytic lesion that develops on the gingiva and alveolar ridge. Although the precise etiology of this lesion is unknown, it could represent a local reaction to trauma or irritation. Management requires a surgical excision of the lesion and elaborate recall due to possible recurrence. This report describes the clinical and histopathological features and management of a peripheral giant cell granuloma as it appeared in the maxillary anterior region of a 35-year-old female patient.

Peripheral giant cell granuloma (PGCG) (also known as giant cell epulis) is the most common giant cell lesion in the oral cavity.1 Generally, it is an asymptomatic hyperplastic lesion of the attached gingiva or alveolar mucosa that is believed to originate from the gingival connective tissue or the periosteum of the alveolar ridge.2 It manifests as a soft tissue, extra-osseous, purplish-red nodule consisting of multinucleated giant cells with a background of mononuclear stromal cells and extravasated red blood cells. This lesion may not represent a true neoplasm but rather could be a reactive lesion. It is believed that this lesion is stimulated by local irritation or trauma; however, its precise etiopathogenesis is still unclear.1

This article describes the clinical and histopathological findings of a PGCG in a female patient.

Case report
A 35-year-old woman presented with the chief complaint that her gums in the maxillary left anterior region had progressively increased in size over the last three months. Besides causing esthetic concerns, this enlargement had led to pain and difficulty with mastication. The systemic history of the patient was noncontributory. The patient did not report any history of trauma or irritation related to this region. Extraoral examination showed incompetent lip seal and mild swelling in the left labial region. Intraoral examination revealed an enlarged (5 mm x 10 mm), pedunculated, reddish-purple lesion in the area of tooth No. 23 (maxillary left canine) extending from the gingival margin to the vestibule. A focal surface ulceration was seen on the lesion (Fig. 1). The lesion itself was tender and bled easily upon slight manipulation; in addition, it displayed a soft consistency upon palpation. The tooth was vital and nonmobile. A periapical radiograph showed a generalized widening of the periodontal ligament space and mild crestal bone loss on the maxillary lateral incisor (Fig. 2). The patient’s oral hygiene was found to be satisfactory; a small amount of calculus was seen.

A provisional diagnosis of irritational fibroma was made and an excisional biopsy was planned after thorough hematological investigations (all of which were within normal range) were conducted. After informed consent was obtained from the patient, the lesion was excised under local anesthesia and sent for histopathological examination (Fig. 3).

Microscopic examination of an H&E-stained section showed proliferative orthokeratinized and parakeratinized stratified squamous epithelium. In some places, epithelium showed short broad or flat rete ridges. Underlying connective tissue stroma was dense fibrocellular tissue interspersed with fibroblasts; in addition, many multinucleated giant cells were seen scattered throughout the stroma (Fig. 4 and 5). Stroma also showed irregular trabeculae of vital bone. The tissue was adequately vascular with small to large dilated single endothelially lined blood vessels with intravasated red blood cells. Hemorrhagic areas were also seen. Dense, diffuse, chronic inflammatory infiltrate (consisting primarily of lymphocytes and plasma cells) was also visible (Fig. 6). Based on these findings, PGCG was diagnosed.

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At a follow-up visit 7 days after surgery, the patient demonstrated a satisfactory healing response. A 6-week follow-up showed no recurrence of lesion (Fig. 7). The patient was previously informed that excising the lesion could result in root exposure, which would require additional corrective periodontal plastic surgical procedure; the patient declined the procedure for personal reasons.

Discussion

PGCG is an exophytic lesion that begins in the gingiva and alveolar ridge; it is believed to originate from the gingival connective tissue or the periosteum of the alveolar ridge. PGCG is not a neoplasm but rather a reactive lesion caused by local irritation. Though the etiology of PGCG is unclear, many hypotheses have been proposed. Some studies have suggested that a history of trauma is responsible for the development of PGCG. According to Shields, the proliferation of giant cells associated with the resorption of primary teeth may be involved in the development of PGCG, which explains how these lesions occur in children but does not explain how they appear in edentulous patients. Other factors that have been implicated as predisposing factors in giant cell lesions include hormonal disturbances, primary and secondary hyperparathyroidism (that is, secondary to chronic renal disease), irritation due to dental restorations or ill-fitting dentures, tooth extractions, orthodontic therapy, plaque, and calculus. In addition, children with X-linked hypophosphatemic rickets (that is, subclinical hyperparathyroidism) are also at an increased risk of developing PGCG.

A 1995 review by Stratakis et al concluded that women had a slightly higher prevalence of PGCG, and patients between fourth and sixth decades were more prone to the development of PGCG. Lesions have been found more frequently in the mandible than in the maxilla, and usually between the first permanent molar and the incisors; however, even though the lesion in this case appeared between the first permanent molar and the incisors, it was found in the maxilla.

Florid granulation tissue is one of the primary histopathological features of PGCG. The lesions also are characterized by the presence of a non-capsulated, highly cellular mass with abundant multinucleated giant cells, inflammatory cells, interstitial hemorrhage, hemosiderin deposits, and mature bone or osteoid. A varying number of chronic inflammatory cells and neutrophils usually are present in underlying ulcerated areas; however, the abundance of multinucleated giant cells are the main feature that differentiates PGCG from other reactive lesions. All of these features were observed during the histopathological examination of this lesion.

Radiographic evaluation is prudent to determine the extent and origin of a lesion. Superficial resorption or cupping of alveolar bone is seen frequently in radiographs. A widened periodontal ligament space may represent extrusion of the lesion around the root. In the present case, mild crestal bone loss in the maxillary lateral incisor and generalized widening of periodontal ligament spaces were observed.

Giant cells are multinucleated cells. The origin of giant cells is still not clear, but these cells may represent a reaction to unknown stimuli. Some authors believe that multinucleated giant cells originate from osteoclasts while others believe they derive from macrophages. There is a growing body of opinion that giant cells are derived from bone marrow mononuclear cells and reach the site via bloodstream. They represent a reactionary response to unknown stimuli from stroma. These concepts on the origins of giant cells are based on the results of various studies using cell culture and transplantation in which giant cells have been found to be short-lived and disappear early in the culture in contrast to active proliferation of stromal cells.

A 1995 study by Lim & Gibbins confirmed that the multinucleated giant cells reacted strongly to a monoclonal antibody.
(MB1), which reacts with lymphocytes and a proportion of T cells and monocytes. The MB1 antibody is expressed by osteoclasts in fetal bone. Although PGCG lesions appear to be extremely vascular, the re-expression of the blood vessels in the lesion (for the widely used endothelial cell marker factor VIII-related antigen) failed to demonstrate the presence of blood vessels anywhere but on the periphery of the lesion. A 1998 study by Rammer et al showed an increased expression of two apoptotic proteins (bak and bax) in osteoclasts such as giant cells, which supports the theory that giant cells are reactive and not neoplastic.

A 1990 study by Bonetti et al showed that giant cells did not react to antibodies with myelomonocytic and macrophage markers (including lysozyme, Mac 387, and HAM 56), while they showed strong immunoreactivity with antibodies directed to osteoclast surface markers. More recently, Liu et al concluded that receptor activator NF-κB ligand (RANKL), osteoprotegerin (OPG), and RANK may play a role in osteoclastogenesis. Willing et al concluded in their 2001 study that monocyte chemoattractant protein-1 (MCP-1), osteoclast differentiation factor (ODF), and macrophage-colony stimulating factor (M-CSF) are monocyte chemoattractants that are essential for osteoclast differentiation. These molecules stimulate blood monocyte immigration into tissue and enhance their fusion into osteoclast-like multinucleated giant cells.

Disintegrin and metalloproteinase may play a role in the multinucleation of monocytic precursor cells into osteoclasts and macrophage-derived giant cells. Woven bone and lamellar bone are found routinely in PGCG, which can be attributed to proliferative osteoblasts or osteoprogenitor cells developing in response to intense irritation of the periosteum. Mineralized tissue has also been reported.

Most lesions respond well to surgical excision and the elimination of local irritating factors, with a recurrence rate of approximately 10% that can be attributed mainly to failure to eliminate all local factors. In the present case, a residual recession of 3 mm was found near the maxillary left canine and lateral incisor, which could be treated by root coverage procedures.

PGCG can be differentially diagnosed from pyogenic granuloma, parulis, peripheral ossifying fibroma, and hemangioma on the basis of histopathological examination.

Conclusion
Although PGCGs are benign, they can be locally aggressive. In case of isolated gingival enlargement, histopathological investigation is compulsory to confirm clinical diagnosis. Surgical excision and planned recall are the keys to proper management.

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