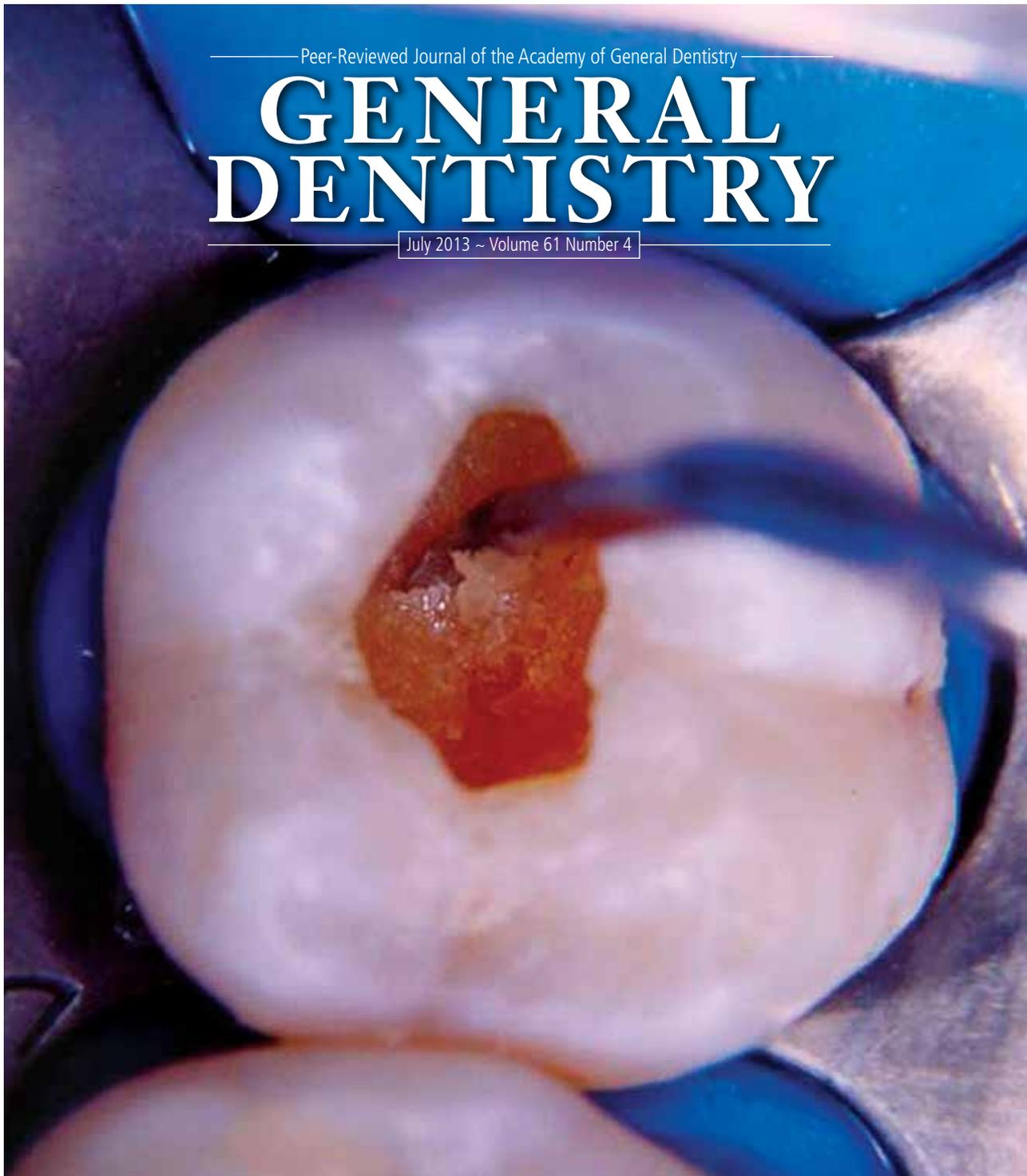


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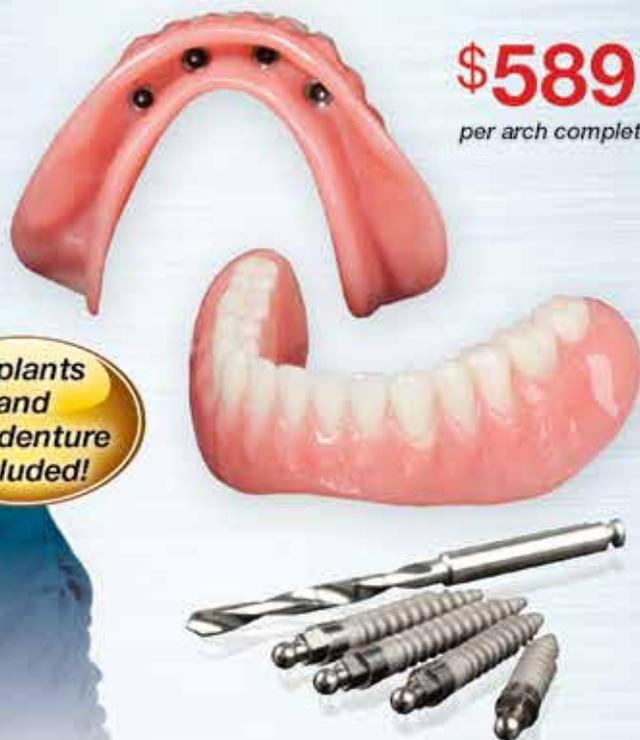


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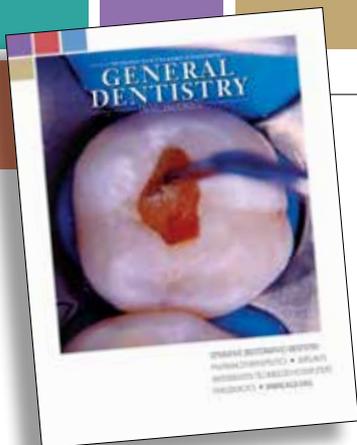
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2 West Taunton Ave.

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## Reprints

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# Fostering change

Among the species of the blackbird family, there is a bird commonly known as the *brown-headed cowbird*. This species is known for its unusual approach to raising its young. Rather than building their own nests, brown-headed cowbird females lay their eggs in the nests of other birds, in effect abandoning their young to “foster” parents, usually at the expense of the host’s own chicks due to competition for food.



In my practice, I daily advise grandparents who serve as foster care guardians for their grandchildren. This phenomena is part of what appears to be an evolving trend among recent generations. Most of these grandparents are supported by Medicare, while their grandchildren, as part of the foster care program, are on Medicaid. The parents of these children are unable to support them. If this trend continues, who will take care of subsequent generations? I have spent the last 40 years of private practice trying to make a difference in the oral health of this low-income population, but have not made the smallest dent. Recently, my office staff and I concluded that only an increase in oral health literacy will make a difference. Prevention, not reconstruction, is the answer.

Some, such as Straus & Howe (in their 1997 book, *The Fourth Turning*) believe that hope lies with the post-millennial generations. The hope is that these generations will be more inclined to support their families as did their grandparents and great-grandparents, with parents raising their own children, thus reversing the trend of grandparents serving as foster guardians.

The retailer/philosopher Marshall Field wrote a list of *Twelve Things to Remember*, which can be a helpful guide to recapturing a sense of the values of earlier generations:

1. The value of time.
2. The success of perseverance.
3. The pleasure of working.
4. The dignity of simplicity.
5. The worth of character.
6. The power of kindness.
7. The influence of example.
8. The obligation of duty.
9. The wisdom of economy.
10. The virtue of patience.
11. The improvement of talent.
12. The joy of originating.

Following this guide in our personal and professional lives can be beneficial not only to ourselves, but to those around us.

As we move forward in our daily lives, we must remember to hold on to our values. We may have lost some traditional family values in recent generations, but we have not lost our way to the future. Unlike the brown-headed cowbird, we have a motivation to change. As long as we are not content with where society is, and are willing to work for what it could be, there is hope. True maturity comes when we realize that no one will constantly come to the rescue. Life is a series of good and bad events. Each day we are presented with fresh possibilities and new obstacles, and inevitably, it is up to us as to how we deal with them.

Roger D. Winland, DDS, MS, MAGD  
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# Microbiological evaluation of ultrasonic nebulization for disinfecting dental impressions

Marcio Jose Mendonca, DDS, MSc, PhD ▪ Renata Santos Rafael, DDS ▪ Veridiana Camilotti, DDS, MSc, PhD  
 Rafael Andrade Menolli, MSc ▪ Eliseu Augusto Sicoli, DDS, MSc, PhD ▪ Nancielli Teixeira, DDS  
 Mario Alexandre Coelho Sinhoreti, DDS, MSc, PhD

Disinfecting dental impressions is necessary to decrease the risk of cross-contamination in dental offices. Ultrasonic nebulization has been mentioned as a microbicidal technique that can be used to disinfect contaminated dental impressions. This study compared the microbicidal effect of 2% glutaraldehyde and 0.2% peracetic acid for the disinfection of dental impressions made with vinyl polysiloxane, using 2 disinfection methods: immersion and ultrasonic nebulization. Bactericidal efficacy was examined using *Staphylococcus aureus* and *Bacillus atrophaeus* as indicators. Thirty impressions were obtained and distributed randomly in 5 groups (n = 6). Group 1 was immersed in 2% glutaraldehyde solution for 10 minutes, Group 2 was immersed in 0.2% peracetic acid solution for 10 minutes, Group 3 underwent ultrasonic nebulization for 10 minutes in 2% glutaraldehyde solution, Group 4 underwent

ultrasonic nebulization for 10 minutes in 0.2% peracetic acid solution, and Group 5 was a control group that received no disinfectant. Both solutions experienced a 100% reduction in microorganisms following ultrasonic nebulization, as did peracetic acid following immersion; however, immersion in glutaraldehyde demonstrated lower values of reduction in the *B atrophaeus* group, with a statistically significant difference compared with the other experimental groups.

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Dental professionals make contact with a large variety of microorganisms in patient blood and saliva, and in the aerosols produced during treatment. Many of these microorganisms may cause infectious diseases, such as hepatitis B, tuberculosis, herpes, pneumonia, and AIDS.<sup>1,2</sup> As clinical procedures involving complex equipment and instruments are performed, these infectious diseases may be transmitted from the patient's oral cavity to the environment, leading to the risk of cross-infection.<sup>3</sup>

The dental team must follow universal infection control recommendations, treating all patients as potential carriers of pathogenic microorganisms.<sup>2</sup> Procedures and precautions in the dental office and dental laboratories have been created to prevent cross-contamination. These procedures involve increased personal protection and eliminating pathogenic microorganisms in dental materials (such as impression materials and stone casts sent to prosthesis laboratories).<sup>4</sup> Impressions are considered contaminated when the material makes contact with sources of contamination (such as saliva and blood) during the impression technique. After taking an impression, a large number of microorganisms from the oral flora will be transferred upon removal from the mouth. Impressions and prosthodontics carry the greatest potential for

transmitting bacteria between a patient and the dental team.<sup>5,6</sup> Retention of these oral microorganisms on impression surfaces is expected, and could be transferred to the stone casts, thus placing those who handle them at risk, as well.<sup>4,7-9</sup> As a result, it is essential to decontaminate the impressions.<sup>7</sup> Effective infection control measures must be mandatory in dental offices and dental prosthesis laboratories to reduce the potential for cross-infection.<sup>6</sup>

Even after impressions are rinsed initially to remove saliva, blood, and debris, a significant number of pathogenic microorganisms remain adhered to impression surfaces.<sup>1,5,9</sup> For this reason, the ADA recommends using both a disinfectant solution for impressions and washing them under running water.<sup>1</sup>

Among chemical disinfectants, glutaraldehyde has been used widely. It is compatible with many materials and has demonstrated bactericidal, fungicidal, and virucidal effects.<sup>10,11</sup> However, glutaraldehyde releases toxic vapors, irritants, and allergens that can irritate the eyes, nose, and throat, and affect patients with allergies, contact dermatitis, asthma, and rhinitis.<sup>12</sup> Moreover, it must be used in well-ventilated places and handling requires masks, gloves, and goggles.<sup>13</sup> Recent reports of bacteria outbreaks

involving mycobacteria and bacilli have led some researchers to question the bactericidal potential of glutaraldehyde.<sup>14,15</sup>

Peracetic acid has been considered an effective and safe alternative to glutaraldehyde by the FDA, the CDC, and the Association for Professionals in Infection Control and Epidemiology.<sup>3</sup> A powerful microbicidal agent, peracetic acid is used in hospitals for sterilizing hemodialyzers and for high-level disinfection. According to the FDA, peracetic acid is a nontoxic, nonallergenic agent. It is considered a mild irritant, indicated for high-level sterilization and disinfection.<sup>16</sup>

In addition to disinfection by immersion, the method of disinfection by nebulization has been discussed in the literature.<sup>17</sup> This method is used especially in medical treatments.<sup>18</sup> Nebulization involves dispersing a liquid substance into the air; in the case of ultrasonic nebulizers, the aerosol is produced by vibrating the piezoelectric crystal that emits ultrasonic waves.<sup>18</sup> According to Steckel & Eskandar, performing this type of nebulization for 10 minutes produces an aerosol with very small particles (approximately 1.13 µm).<sup>19</sup> This size allows the disinfectant to penetrate into the surface of the impression material more effectively, improving the microbicidal effect of disinfectant solutions.

**Table 1. Effectiveness of disinfectants in removing *S aureus*.**

Groups	<i>S aureus</i>		
	Post-treatment CFU/ml (SD) <sup>a</sup>	Removal rate (%)	RF
1	0.00 (± 0.00)	100	6.79
2	0.00 (± 0.00)	100	6.79
3	0.00 (± 0.00)	100	6.79
4	0.00 (± 0.00)	100	6.79
5	6.11 x 10 <sup>6</sup> (± 2.92 x 10 <sup>6</sup> )	N/A	N/A

<sup>a</sup>Mean final counts, after disinfectant treatment.  
RF: logarithmic reduction factor

**Table 2. Effectiveness of disinfectants in removing *B atrophaeus*.**

Groups	<i>B atrophaeus</i>		
	Post-treatment CFU/ml (SD) <sup>a</sup>	Removal rate % <sup>b</sup>	RF
1	2.75 x 10 <sup>5</sup> (± 7.78 x 10 <sup>4</sup> )	89.13 <sup>b</sup>	0.97
2	0.00 (± 0.00)	100.00	6.40
3	0.00 (± 0.00)	100.00	6.40
4	0.00 (± 0.00)	100.00	6.40
5	2.53 x 10 <sup>6</sup> (± 4.49 x 10 <sup>5</sup> )	N/A	N/A

<sup>a</sup>Mean final counts, after disinfectant treatment. <sup>b</sup>Statistically significant (*P* < 0.05).  
RF: logarithmic reduction factor

This study sought to compare the microbicidal effect of 2% glutaraldehyde and 0.2% peracetic acid on dental impressions made of vinyl polysiloxane, using immersion and ultrasonic nebulization.

## Materials and methods

Vinyl polysiloxane (Aquasil Ultra LV, DENTSPLY Caulk) was used and manipulated in accordance with the manufacturers' instructions. Staphylococci normally are used as test microorganisms for low-level hospital disinfectants, while bacilli normally are used for testing high-level hospital disinfectants. To evaluate the bactericidal efficacy of the ultrasonic nebulization method and the immersion method, two disinfectants were used: 0.2% peracetic acid and 2% glutaraldehyde. The microorganisms *Staphylococcus aureus* and *Bacillus atrophaeus* were used. A nebulizer was set at an ultrasonic frequency of 2.4 MHz, with a nebulization rate of 1.25 cc/minute. The disinfectant solution mist was guided into an airtight and transparent plastic box (20 cm x 20 cm x 25 cm), sterilized by ethylene oxide. The samples in the box were disinfected for 10 minutes with ultrasonic nebulization until the box was saturated by fog.<sup>17</sup>

The vinyl polysiloxane dental impressions were made using a sterilized stainless steel pattern model, using previously described fabrication methods.<sup>4,8</sup> At that point, the samples were contaminated artificially for 60 minutes with 10 µL of *S aureus* or 10 µL of *B atrophaeus*, using a saline solution with turbidity corresponding to a bacterial concentration of 0.5 on the McFarland

scale (1.5 x 10<sup>8</sup> colony-forming units per milliliter [CFU/mL]). After contamination, the impressions were washed in a sterilized saline solution for 10 seconds.<sup>7,12</sup> Next, the impressions were distributed randomly into 5 groups (n = 6) for each microorganism. Groups were distinguished as follows: Group 1 samples were immersed in 2% glutaraldehyde for 10 minutes, Group 2 samples were immersed in 0.2% peracetic acid for 10 minutes, Group 3 samples were placed in 2% glutaraldehyde and received ultrasonic nebulization for 10 minutes, and Group 4 samples were placed in 0.2% peracetic acid solution before undergoing ultrasonic nebulization for 10 minutes. Group 5 was a control group that received no disinfectant treatment. After immersion or ultrasonic nebulization, the impressions were immersed in 90 mL of a sterilized saline solution. To recover the microorganisms, this solution was agitated mechanically for 120 seconds and 20 µL was inoculated with the aid of a disposable calibrated loop into petri plates containing Mueller Hinton agar (Thermo Fisher Scientific, Inc.). After 48 hours of incubation (at 37°C), the authors analyzed the estimated number of CFU/mL in the plates that showed bacterial growth.

The percentage of removal rate for each species of microorganism tested was calculated by using the formula: removal rate (%) = 100 x (treated/control). The bactericidal efficacy was expressed by the logarithmic reduction factor (RF), calculated by means of the following equation: log<sub>10</sub> reduction = log<sub>10</sub> (CFU/mL) of the control group - log<sub>10</sub> (CFU/mL) of the disinfection group.

Analysis of variance (ANOVA) was used to compare the removal rates of each test specimen. A value of *P* < 0.05 was considered significant. Post hoc comparison was made using the Tukey test.

## Results

For *S aureus*, all evaluated groups demonstrated a removal rate of 100% and an RF of 6.79, based on the initial bacterial concentration of 6.11 x 10<sup>6</sup>. Table 1 indicates that *S aureus* did not demonstrate statistically different data among the different groups.

For samples with *B atrophaeus*, Groups 2-4 demonstrated a removal rate of 100% and an RF of 6.40. By contrast, Group 1 demonstrated a removal rate of 89.13% and an RF of 0.97, which was significantly different from the other experimental groups (Table 2).

## Discussion

Despite earlier recommendations in the literature, the efficacy of glutaraldehyde against some microorganisms has been questioned in recent years. A 2002 study by Grande et al disinfected a bronchoscope with 2% glutaraldehyde for 20 minutes, and reported the growth of some microorganisms; as a result, the disinfection process was considered insufficient.<sup>14</sup> More recently, Pineau et al verified that the 2% glutaraldehyde solution promoted protein accumulation and fixation during the reprocessing of endoscopes, compared with the 0.15% peracetic acid solution.<sup>15</sup> Based on these findings, glutaraldehyde has been

discontinued for disinfecting reusable medical devices in pursuit of a solution that will not promote this fixation.

Peracetic acid acts rapidly and efficaciously against bacteria, fungi, and viruses. Unlike the majority of chemical disinfectants (including glutaraldehyde), peracetic acid is not made inactive by the presence of organic matter.<sup>13</sup> It does not leave residues and produces no noxious byproducts; in addition, it is safe for the patient, operator, and the environment, since its end products are water, oxygen, and carbon dioxide.<sup>11</sup> Peracetic acid acts by oxidation and is effective against all microorganisms, even when used in low concentrations.<sup>3,9</sup> A 2006 study by Chassot et al recommended that peracetic acid should replace glutaraldehyde and also should be used to control and minimize the risk of cross-contamination.<sup>3</sup> More recently, Ceretta et al demonstrated the efficacy of peracetic acid, which promoted complete sterilization of dental instruments when used for 20 minutes at a concentration of 2,500 ppm.<sup>9</sup>

This study evaluated the disinfectant solutions, glutaraldehyde and peracetic acid, by immersion and by a new disinfection method of ultrasonic nebulization. The latter process was first examined in 2008 when Wu et al evaluated how electrolyzed oxidizing water affected dental impressions made of alginate.<sup>17</sup> Ultrasonic nebulization occurs when a piezoelectric device generates ultrasonic vibration and breaks the disinfectant solution into very small particles, making it easier for those particles to penetrate their target. Since this nebulization occurs inside a closed receptacle, the dental impression is in an environment saturated with 100% disinfectant solution vapor, which favors the integrity of the impression material, as the chance of direct contact with the solution is diminished.<sup>17</sup> This way, the ultrasonic nebulization method could provide more accurate casts in crown and prostheses preparations. Additionally, ultrasonic nebulization is economical when compared to the immersion methods, as the process only needs a small quantity of disinfectant (10 ml).

Based on a comparative evaluation of the 2 disinfectant solutions, both reduced *S aureus* by 100%, regardless of whether immersion or nebulization was performed. *S aureus* is a Gram-positive bacteria

that is included frequently in infection control studies because of its important pathogenicity and its resistance to drying, heat, and some disinfectant agents.<sup>20</sup> In addition, this microorganism is a causative pathogen of respiratory infections that frequently is isolated from both complete dentures and the oral cavity.<sup>21</sup> The results for glutaraldehyde and peracetic acid solutions were expected due to the microbicidal effectiveness of these solutions. Peracetic acid is considered a strong disinfectant with a great amount of antimicrobial activity.<sup>22</sup> Glutaraldehyde is a powerful microbicidal agent, although not all microorganisms are equally susceptible to this solution.<sup>23</sup>

When *B atrophaeus* was used, nebulization produced a reduction rate of 100% for the two tested solutions. However, when immersion was used, the peracetic acid had a reduction rate of 100%, while the glutaraldehyde solution showed a reduction rate of 89.13%. *B atrophaeus* is commonly used as a biologic marker to monitor sterilization processes and for evaluating disinfection procedures and microbiologic barriers.<sup>17</sup> Studies have reported *B atrophaeus* showed greater resistance to glutaraldehyde compared with other species.<sup>24</sup> In addition, the microbicidal capacity of glutaraldehyde depends on the concentration, temperature, and pH of the disinfectant solution.<sup>23</sup> In this study, it was possible to verify that the nebulization method presented superior antimicrobial activity against *B atrophaeus*, compared to the immersion process, thus presenting ultrasonic nebulization as a safe alternative to the immersion method.

The differences found for the ultrasonic nebulization and immersion methods may be explained by the fact that disinfection involves a combination of physical and chemical processes, and each method uses different physical processes.<sup>25</sup> A 2003 study by Steckel & Eskandar verified that ultrasonic nebulization affected the droplet size, surface tension, viscosity, and saturated vapor pressure that can result from changes in temperature change and solution concentration in the nebulizer.<sup>19</sup> These changes could explain why using the glutaraldehyde solution with a ultrasonic nebulizer had a superior effect against *B atrophaeus* compared to immersion. It is possible that the ultrasonic nebulization

of glutaraldehyde solution depended on the increase in the concentration of this solution. In addition, the possible increase of saturated vapor pressure may have given the disinfectant solution more effective contact on the impression, contributing to the superior microbicidal effect when the glutaraldehyde solution was nebulized ultrasonically.

## Summary

Although ultrasonic nebulization demonstrated positive results in this study, additional research is necessary to evaluate this method regarding the quality of the casts, as well as the evaluation of other disinfectants and impression materials. The results of this study indicate that ultrasonic nebulization is an effective microbicidal method for polyvinylsiloxane impressions when either a 2% glutaraldehyde solution or a 0.2% peracetic acid solution is used. The immersion method is significantly less effective with 2% glutaraldehyde against *B atrophaeus* compared to 0.2% peracetic acid.

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## Author information

Drs. Mendonca, Sicoli, and Camilotti are adjunct professors, Department of Prosthodontics, Dental School, Western Parana University, Cascavel, Brazil, where Drs. Rafael and Teixeira are post-graduate students in the Dental School, and Dr. Menolli is an assistant professor, Laboratory of Microbiology and Immunology. Dr. Sinhoreti is an adjunct professor of Dental Materials Area, Department of Restorative Dentistry, Dental School of Piracicaba, State University of Campinas, Piracicaba, Brazil.

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# Gingival biotype: a review

Zeinab Rezaei Esfahrood, DDS, MS ▪ Mahdi Kadkhodazadeh, DDS, MS ▪ Mohammad Reza Talebi Ardakani, DDS, MS

Among the factors that may impede success in dental treatments, gingival biotype is the greatest cause of concern, particularly affecting the outcomes of periodontal therapy, root coverage procedures, and implant placement. Different tissue biotypes respond differently to inflammation and to surgical and restorative treatment; consequently, it is crucial to identify tissue biotype before treatment. Special care must be taken when treatment planning for cases with a thin gingival biotype.

This article reviews the characteristics of various gingival biotypes and the many ways to determine them.

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In 1969, Ochslein & Ross indicated that there were 2 main types of gingival anatomy—*flat* and *highly scalloped*.<sup>1</sup> The authors reported that flat gingiva was associated with a square tooth form, while scalloped gingiva was associated with a tapered tooth form. The authors also proposed that the gingival contour closely mimics the contour of the underlying alveolar bone.<sup>1</sup> The term *periodontal biotype* was used later by Seibert & Lindhe, who classified the gingiva as either *thin-scalloped* or *thick-flat*.<sup>2</sup> In a study by De Rouck et al, the thin gingival biotype occurred in one-third of the study population and was most prominent among women, while the thick gingival biotype occurred in two-thirds of the study population and occurred mainly among men.<sup>3</sup>

Studies have confirmed that central incisors with a narrow crown form are at greater risk of recession than incisors with a wide, square form.<sup>4,5</sup> According to the literature, the alveolar bone and the gingival margin surrounding a tooth with pronounced cervical convexity are located more apically than they would be in teeth with flat surfaces, suggesting that the gingival margin is affected by the cervical convexity of the crown.<sup>6,7</sup>

Generally, facial gingival is thicker in the maxilla than in the mandible. Maxillary canines and mandibular first premolars have the thinnest gingiva (0.7-0.9 mm), with a relatively high incidence of gingival recession.<sup>8,9</sup> According to Weisgold, individuals with a thin, scalloped gingiva demonstrated a greater prevalence of recession.<sup>10</sup> Scalloped gingiva can be categorized as *high*, *normal*, and *flat*. The normal scalloped gingiva is 4-5 mm coronal to the free gingival margin.<sup>11</sup>

The alveolar crest in a healthy periodontium is positioned approximately 2 mm more apically than the cemento-enamel junction (CEJ) and mimics the scallop of the CEJ. In the normal and high scalloped gingival form, there is more tissue coronal to the interproximal bone than the facial bone. As such, higher scalloped gingiva are at greater risk for gingival loss after tooth extraction.<sup>12</sup>

In a 1994 article, Kois examined crestal bone levels and classified them as *normal* (crestal bone level is 3 mm apical to the CEJ), *high* (crestal bone level is <3 mm apical to the CEJ), and *low* (crestal bone level is >3 mm apical to the CEJ and found in patients with recession).<sup>11</sup>

Gingival biotype can affect the results of periodontal therapy, root coverage procedures, and implant placement.<sup>3,13-16</sup> It has been shown that patients with thin gingival biotype were more likely to experience gingival recession following nonsurgical periodontal therapy.<sup>13</sup> Mucogingival problems may result from orthodontic movement of teeth away from the alveolar process, particularly among patients with thin periodontium.<sup>17,18</sup> The level of gingival thickness before regenerative surgery was found to be a predicting factor for further recession.<sup>19,20</sup> Kois proposed that postsurgery clinical results were strongly associated with the gingival and alveolar crest form.<sup>12</sup> In cases with low alveolar crest position, an increased susceptibility for gingival recession may expose restorative margins when finish lines are placed intracrevicularly. Patients with thick gingiva appear less likely to experience gingival recession after surgical or restorative therapy.<sup>19-22</sup>

Differences in gingival and osseous architecture have a significant impact on the outcome of treatments. Therefore, gingival biotype should be evaluated at the start of the treatment plan for the most esthetic results. The characteristics of thin and thick gingiva are listed in the Table.<sup>2,3,10,13,23,24</sup>

## Gingival biotype and labial plate thickness

For patients with a thin gingival biotype, extreme care should be taken during extraction to prevent labial plate fracture. Cook et al evaluated the correlation between labial plate thickness and thin or thick gingival biotypes—using information obtained from cone beam computed tomography (CBCT), diagnostic impressions, and clinical examinations of maxillary anterior teeth—and concluded that a significant association existed between gingival biotype and labial plate thickness.<sup>25</sup> According to Fu et al, the thickness of the labial gingival tissue has a moderate association with the underlying bone.<sup>26</sup>

## Gingival biotype and Schneiderian membrane thickness

The most common complication during sinus graft procedures is perforation of the sinus membrane. This condition may occur after the sinus floor is accessed through the lateral wall or the ridge crest.<sup>27-29</sup> Clinical observations have prompted clinicians to suggest a correlation between the sinus membrane thickness and the risk of perforation.<sup>30,31</sup>

A 2008 study by Aimetti et al took maxillary mucosal biopsies from the sinus floor during otorhinolaryngologic surgical interventions, and measured gingival

thickness in the area of the maxillary anterior teeth.<sup>32</sup> The authors reported that the average thickness of the Schneiderian membrane was  $0.97 \pm 0.36$  mm. Patients with thick gingiva had a sinus mucosa that was  $1.26 \pm 0.14$  mm thick, compared to  $0.61 \pm 0.15$  mm thickness among patients with thin gingiva. The results showed that gingival thickness is a reliable factor for predicting sinus membrane thickness.<sup>32</sup> Additional research must be performed to confirm these data.

### Tissue biotype in implant treatment planning

Studies have examined how mucosal thickness and biologic width affect crestal bone loss around implants.<sup>33,34</sup> A 1996 animal study by Berglundh & Lindhe concluded that thin gingival tissue can lead to marginal bone loss during formation of the peri-implant biologic width.<sup>35</sup> Another histologic study by Huang et al reported that implant sites with thin mucosa were prone to angular bone defects, while stable crestal bone was maintained in implants surrounded by thick mucosa.<sup>14</sup> According to Abrahamsson et al, thick tissues (that is,  $\geq 2.5$  mm) can avoid significant crestal bone recession; however, the authors recommend avoiding supracrestal placement of implants if an implant is surrounded by a thin biotype.<sup>36</sup>

Gingival recession is one of the most common complications resulting from single anterior tooth implant placement.<sup>37</sup> Gingival biotype is a diagnostic key for predicting the esthetic success of an implant.<sup>12</sup> According to Evans & Chen, gingival recession increases in patients with thin biotypes immediately after single implant restorations.<sup>22</sup> Furthermore, papilla between immediate single implants and adjacent teeth is significantly associated with a thick gingival biotype. Patients with thick-flat mucosa tended to maintain the implant papillae height.<sup>38</sup>

Dramatic alveolar resorption in the apical and lingual direction is possible in patients with a thin biotype.<sup>39</sup> The loss of peri-implant tissues may result in facial plate loss, with the implant taking on a grayish color; additional bone and soft tissue grafting surgeries may be necessary in such cases. Immediate placement of an implant in a thick gingival biotype offers predictable results.<sup>39</sup>

**Table. Characteristics of thin and thick gingiva.**

Characteristics of thin gingiva	Characteristics of thick gingiva
Narrow zone of keratinized tissue	Large amount of keratinized tissue
Gingival thickness is $< 1.5$ mm, width is 3.5-5 mm	Gingival thickness is $\geq 2.0$ mm, width is 5-6 mm
Pronounced scalloped soft tissue and bony architecture	Flat soft tissue and bony architecture
Slight gingival recession	Gingival margins usually are coronal to the cemento-enamel junction
Dehiscence and fenestrations are usual findings in thin underlying bone	Thick bony plates
Thin marginal bone	Thick marginal bone
Small proximal contact areas located near the incisal edge	Broad, more apically located contact areas
Triangular anatomic crowns	Square anatomic crowns
Slender tooth form	Quadratic tooth form
Subtle cervical convexities in the crown	Marked cervical convexities in the crown
Gingival recession following disease	Deep pocket and intrabony defect formation following disease

A 2007 study by Jung et al evaluated different materials (titanium, ceramized titanium, zirconium, and ceramized zirconium) that were placed under the vestibular mucosa of mandibles of pigs, along with connective tissue grafts of varying thickness.<sup>40</sup> Tissue color was measured by a spectrophotometer. All of the materials changed the color of the thin (1.5 mm) mucosa, with titanium producing the greatest change. In normal (2.0 mm) mucosa, only titanium altered the color. In thick (3.0 mm) mucosa, no changes were observed from any of the materials. The results suggest that it is preferable to use pillars of zirconium for thin peri-implant mucosa, to avoid color changes of the mucosa.<sup>40</sup>

### Gingival biotype and ridge preservation

A thin gingival biotype is associated with a thin alveolar plate; more ridge remodeling has been found in this biotype when compared with thick periodontal biotype. Ridge preservation should be considered for most thin biotype cases. Preservation of alveolar dimensions (such as socket preservation or ridge preservation techniques after tooth extraction) is critical for achieving optimal esthetic results in thin biotypes; atraumatic extraction also may be necessary.<sup>41,42</sup>

### Tissue biotype and root coverage

According to McFall, tissue thickness in the recipient site and the donor site are

key factors in how mucogingival defects are treated.<sup>43</sup> In cases involving root coverage surgeries, a flap thickness of 0.8-1.2 mm produced more predictable outcomes.<sup>14,15,20</sup> An initial gingival thickness was found to be the most predictable factor for predicting the success of complete root coverage procedures.<sup>20</sup> There is a correlation between flap thickness and complete root coverage.<sup>15</sup>

### Gingival biotype assessment

Many methods (both invasive and non-invasive) have been used to evaluate the thickness of facial gingival and other parts of the masticatory mucosa. These methods include conventional histology on cadaver jaws, injection needles, transgingival probing, histologic sections, cephalometric radiographs, probe transparency, ultrasonic devices, and CBCT.<sup>4,5,8,13,20,44-58</sup>

### Visual evaluation

Simple visual evaluation is used in clinical practice to identify the gingival biotype; however, it may not be considered a reliable method, as it cannot be used to assess the degree of gingival thickness.<sup>1,2,5</sup>

### Probe transparency

The gingival tissue's ability to cover any underlying material's color is necessary for achieving esthetic results, especially in cases of implant and restorative dentistry, where subgingival alloys are used

widely.<sup>59,60</sup> Using a metal periodontal probe in the sulcus to evaluate gingival tissue thickness is the simplest way to determine gingival biotype; with a thin biotype, the tip of the probe is visible through the gingiva. This method is minimally invasive, and periodontal probing procedures are performed routinely during periodontal and implant treatments.<sup>50</sup>

### Modified caliper

A tension-free caliper can only be used at the time of surgery and cannot be used for pretreatment evaluation. A 2010 study by Kan et al of the facial gingival biotype in maxillary anterior teeth compared visual evaluations, the use of a periodontal probe, and direct measurements with a tension-free caliper.<sup>61</sup> The authors reported a statistically significant difference between visual assessment and both the periodontal probe and the tension-free caliper; however, there was no statistically significant difference when comparing the periodontal probe assessment and the tension-free caliper. Based on these results, a periodontal probe in the sulcus is an adequately reliable and objective way to evaluate tissue thickness, whereas visual evaluation of the gingival biotype by itself is not as reliable as the periodontal probe or the tension-free caliper.<sup>61</sup>

### Transgingival probing

Gingival thickness can be measured by using a periodontal probe; a thick biotype has a thickness of  $\geq 1.5$  mm.<sup>45</sup> However, such measurements can be affected by the precision of the probe, the angulation of the probe, and the distortion of the tissue during probing.<sup>26</sup>

### Ultrasonic devices

A 1971 study by Kydd et al was the first to measure the thickness of palatal mucosa using an ultrasonic device.<sup>52</sup> Ultrasonic devices appear to be the least invasive method and offer excellent validity and reliability.<sup>8,62</sup> However, such devices are no longer available commercially; in addition, they make it difficult to both determine the correct position for accurate measurement and successfully reproduce measurements.<sup>26,61</sup>

**Cone beam computed tomography** CBCT scans have been used extensively for hard tissue imaging because of their

superior diagnostic ability. Fu et al measured the thickness of labial gingiva and bone and reported no statistically significant difference between the clinical measurements made with a caliper and radiographic measurements utilizing CBCT scans; however, CBCT measurements may be a more objective method than direct measurement.<sup>26</sup> A plastic lip, tongue retractors, and wooden spatulas can be used to better visualize soft tissue margins.<sup>58</sup>

### Conclusion

By understanding the nature of tissue biotypes, clinicians can employ appropriate periodontal management to minimize tissue resorption and provide more favorable results after dental treatment. A clear cut classification system should be considered to facilitate gingival biotype diagnosis in a practical manner.

### Author information

Dr. Esfahrood is an assistant professor, Department of Periodontics, Dental School, Shahid Beheshti University of Medical Sciences, Evin, Tehran, Iran, where Drs. Kakhkhodazadeh and Ardakani are associate professors.

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**Exercise No. 331 Periodontics Subject Code 490**

The 15 questions for this exercise are based on the article, *Gingival biotype: a review*, on pages 14-17. This exercise was developed by Merlin P. Ohmer, DDS, FAGD, in association with the *General Dentistry Self-Instruction* committee.

Reading the article and successfully completing the exercise will enable you to understand:

- the concept of gingival biotypes;
- how gingival biotype influences restorative dentistry; and
- how gingival biotype influences surgical procedures.

1. \_\_\_\_\_ gingival biotypes are the most sensitive to dental procedures.
  - A. Normal
  - B. Thin
  - C. Thick
  - D. Compromised
2. Gingival biotype may influence all of the following except one. Which is the exception?
  - A. Periodontal therapy
  - B. Root coverage procedure
  - C. Composite resin restoration
  - D. Implant placement
3. Approximately 33% of the population has a thick biotype. Approximately 33% of the population has a thin biotype.
  - 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.
4. The thin biotype has no predilection for sex. The thick biotype has a predilection for sex.
  - 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.
5. Which two teeth typically have the thinnest gingiva?
  - A. Maxillary canines and mandibular canines
  - B. Maxillary canines and mandibular first premolars
  - C. Maxillary canines and maxillary first premolars
  - D. Maxillary first premolars and mandibular first premolars
6. The gingival margin is affected by the \_\_\_\_\_ of the crown.
  - A. convexity
  - B. concavity
  - C. diameter
  - D. arc
7. In a healthy periodontium, the alveolar crest is approximately \_\_\_\_\_ mm apical to the CEJ.
  - A. 1
  - B. 2
  - C. 3
  - D. 4
8. Where is the ideal location for crown margins in patients with thin biotypes?
  - A. Supragingivally
  - B. At the gingival margin
  - C. Subgingivally
  - D. Does not matter
9. In patients with thin biotypes, buccal plate fracture is \_\_\_\_\_.
  - A. more common
  - B. less common
  - C. not a factor
  - D. rare
10. A study has shown a \_\_\_\_\_ relationship between biotype and thickness of the lining of the maxillary sinus.
  - A. positive
  - B. negative
  - C. neutral
  - D. non-
11. One of the most common events following single anterior implant placement is \_\_\_\_\_.
  - A. infection
  - B. recession
  - C. interproximal bone loss
  - D. bone regeneration
12. In root coverage surgeries, a flap thickness of \_\_\_\_\_ mm resulted in more predictable outcomes.
  - A. 0.1-0.3
  - B. 0.4-0.7
  - C. 0.8-1.2
  - D. 1.3-1.6
13. A simple way to evaluate flap thickness prior to surgery is to \_\_\_\_\_.
  - A. blow air in the sulcus
  - B. use a periodontal probe
  - C. use a caliper
  - D. employ visual assessment
14. A thick biotype has a thickness of at least \_\_\_\_\_ mm.
  - A. 0.75
  - B. 1.00
  - C. 1.25
  - D. 1.50
15. \_\_\_\_\_ is considered just as reliable as CBCT in measuring gingival thickness.
  - A. A caliper
  - B. A periodontal probe
  - C. A visual inspection
  - D. Air blown in the sulcus

**Answer form is on page 80. Answers for this exercise must be received by June 30, 2014.**

# Comparison of the efficiency of photography-assisted shade selection to visual shade selection

K. Prabhu, MDS ▪ Padma Ariga, MDS ▪ Jacob Mathew Philip, MDS

This study sought to compare the efficacy of digital photographs and graphic software for shade matching to that of conventional visual shade selection. Thirty-one postgraduate students were used and shade selection was analyzed through 1 of 4 different techniques: digital spectrophotometer, conventional visual shade selection, visual shade selection assisted by digital photography, and shade selection by color difference formulas and computer software.

Shade selection done with digital photography and graphic software using color differences formulas offered better and statistically significant shade matching compared to conventional visual shade selection and visual shade selection assisted by digital photography.

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It can be difficult to measure and analyze shade selection, as several parameters can influence the esthetic outcome of the restoration. Traditionally, shade selection has been performed visually with the help of shade guides. Newer shade guides like VITA 3D-Master (Vident) have yielded better results than their predecessors due to their ease of use.<sup>1</sup> The guide is based on a colorimetric classification principle where the value, chroma, and hue have been positioned at an equal distance to each other; as a result, the shade determination can be performed easily according to systematic criteria.

Although newer shade guides may produce more accurate results, visual shade selection is still influenced by many external variables such as eye fatigue, light source, metamerism, and colorblindness.<sup>2</sup>

According to the literature, computerized colorimetry and spectrophotometry has increased accuracy by 33%.<sup>3</sup> A 2009 study by Gehrke et al found that spectrophotometric shade determination is easier to reproduce than conventional visual shade assessment; in addition, it can serve as a reliable tool in color matching while enhancing the level of shade analysis and the communication, interpretation, and fabrication of dental restorations.<sup>4</sup> Although colorimetric and spectrophotometric digital shade selectors have improved accuracy, the cost of equipment remains high and therefore is not used extensively.

Digital photography can be used in dental shade determination, as in vitro studies have reported advances in dental photography, image, and color analysis

with computer software.<sup>5</sup> Wee et al suggested that combining commercial single-lens reflex digital cameras with the appropriate calibration protocols could be used for the color replication process in clinical dentistry.<sup>5</sup>

The possibility of a clinically acceptable shade match has increased with the use of dental photography. Dental photography is even more useful when the tooth color—including a description of effects such as enamel hypoplasia or decalcification and translucency—is clearly communicated between the clinician and the laboratory technician. The development of a system for shade selection and communication that is simple to use and has a higher rate of predictable success would be economically and clinically viable.

This clinical study sought to compare digital imaging (with the use of a graphic software program for shade selection) with conventional visual shade selection. The null hypothesis is that no difference exists between visual shade selection assisted by digital photography and a selection that utilizes computer software.

## Materials and methods

A total of 35 postgraduate students were selected randomly for the study; a power analysis was performed to determine adequate sample size. The subjects were divided into 4 groups: shade selection by spectrophotometer—considered the gold standard in shade selection—was the control (Group 1); conventional visual shade selection using the VITA 3D-Master shade guide (Group 2); visual shade selection assisted by digital photography and

computer (Group 3); and shade selection made with color difference formulas and graphic software (Group 4).

The criteria for inclusion in the study was any postgraduate student with a vital permanent right upper central incisor. The exclusion criteria of the study were the presence of any restoration, intrinsic or extrinsic stains, and structural and developmental abnormalities of the tooth.

The middle third area of the permanent right upper central incisor was selected for shade analysis. The same investigator analyzed all the groups. Group 1 consisted of shades that were analyzed using a digital spectrophotometer (VITA Easyshade, Vident) and the shades were taken as the control group reading.

For Group 2 samples, shade selection was performed using the conventional VITA 3D-Master shade guide. The subject was seated comfortably in the dental chair and a standard daylight lamp with a color temperature of 6500 K was used. A standard shade selection procedure recommended by the manufacturer was followed. Value (lightness) was selected, followed by hue, and then chroma.

For Group 3 samples, visual shade selection was assisted by using digital photography on a computer. The sample tooth and the shade tabs were placed side-by-side and photographed using a digital single lens reflex camera (Nikon D300, Nikon USA). The same camera settings were used throughout: a twin flash attachment with diffuser, macro lens with auto focus of 100 mm, an aperture of f20, and a shutter speed of 1/125 seconds.<sup>6,7</sup> The distance between the object and the lens was 35 cm. Only

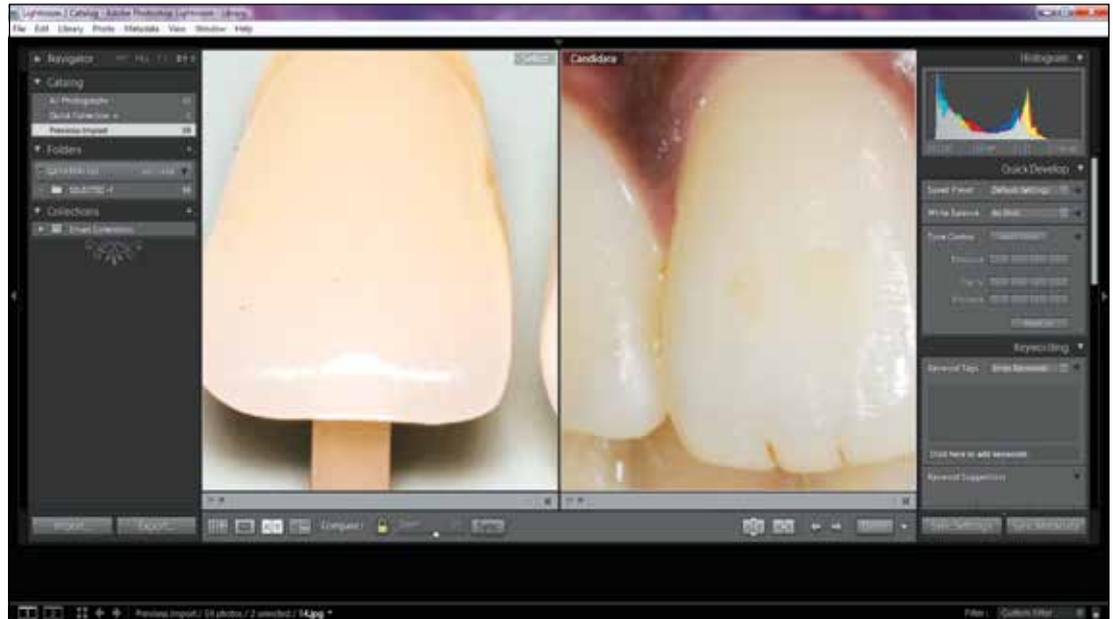


Fig. 1. Shade selection completed with the help of digital photos on a computer.

well-exposed digital photographs were taken for analysis; under- or overexposed photos were discarded and replacement photos were taken. The photos were stored in RAW format. A graphic software program (Adobe Photoshop, Adobe Systems, Inc.) was used to adjust the color temperature of the photos to 4800 K and the photos were then stored in the .jpg format. Shade selection was performed by using a flat screen 15-inch color monitor (Fig. 1).

For Group 4 samples, quantitative shade selection through the use of graphic software was evaluated (Fig. 2). The same images used in Group 3 were analyzed using Adobe Photoshop, which assessed the images in terms of lightness (L), a, and b values. Using the mouse pointer, an area in the test tab and the natural tooth was selected manually in the middle third area of the tooth (Fig. 3). The area selected contained uniform color and the area to be analyzed was marked with Adobe Photoshop's color sampler tool. Areas with uniform color were selected and reflections from the flash were avoided. Standardized color value systems (L\*a\*b\* and RGB) were used, and the natural tooth color and all shade tabs from the shade guide were recorded (Fig. 4). The color differences between the tooth and the test tabs were

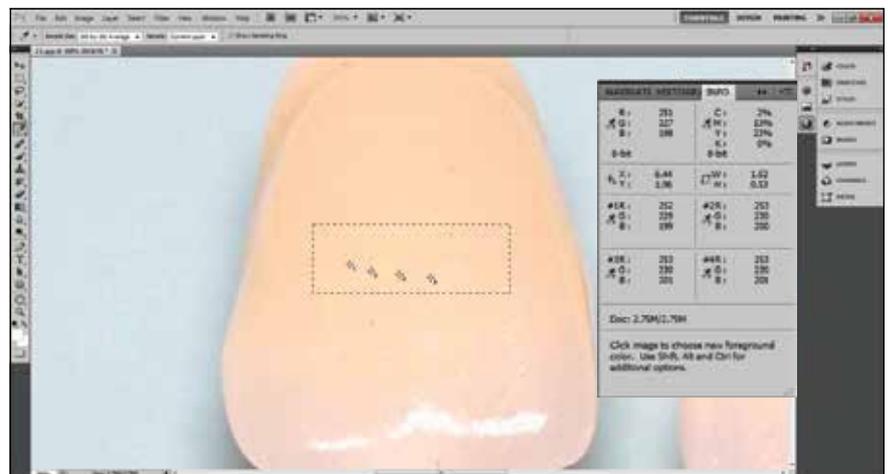


Fig. 2. RGB values are obtained for the tooth and the shade tab for calculating the color difference in a graphic software program.

calculated using the CIELAB formula ( $\Delta E = \Delta L^2 + \Delta a^2 + \Delta b^2$ ).<sup>8</sup> The shade tab which deviated least from the natural tooth was determined to match. A chi-square test was used to compare the various methods of shade selection.

### Results

Of the 35 subjects, 4 opted out of the study. Shades were matched for the remaining 31 subjects (Table 1). Shade

selection in Group 1 (control) was done by a spectrophotometer.

In Group 2, shade selection was done visually in a simulated clinical environment; however, only 10 of the 31 samples (32.3%) had an accurate shade match. A tendency to choose a darker shade was noted in 54% of the samples.

For Group 3, shade selection was done visually, assisted by digital photography on a computer, and 13 of the 31 samples

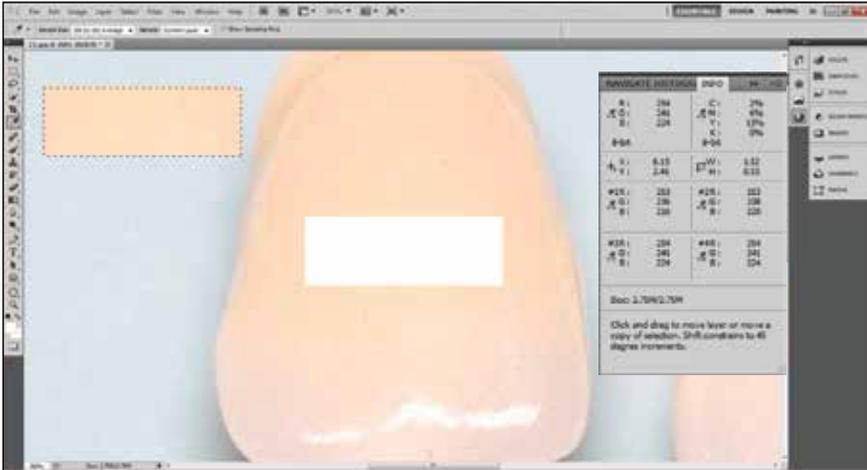


Fig. 3. The middle third region of the tooth and the tab are taken for analysis.

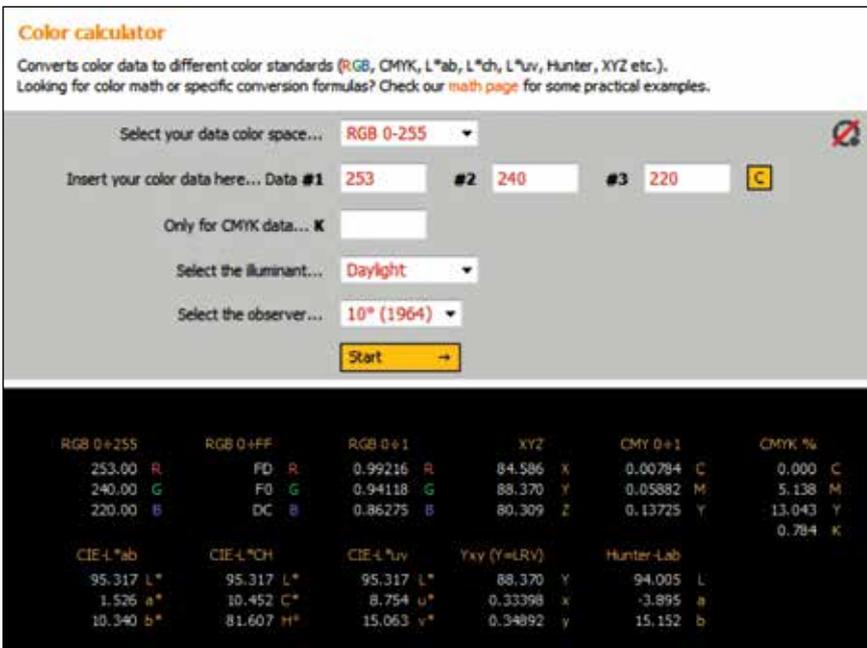


Fig. 4. RGB values are converted to L\*a\*b\* values. Image obtained from www.easyrgb.com.

(41.9%) had an accurate shade match; however, the data did not show any tendencies for lighter or darker shades of the shade tab. These results indicate that visual shade selection assisted by digital photography offered significantly better results than conventional visual shade selection alone ( $P < 0.001$ ).

For Group 4, where graphic software and color difference formulas were used to determine the exact shade, 19 of the

31 samples (61.3%) had an accurate shade match. The chroma variations were relatively difficult to match accurately, due to the variables listed in Table 2. Since the control group shades were selected from the spectrophotometer, the interpolated shades significantly influenced the results of the study. In matching those shades, the constituent of one of the 3-dimensional mixtures were taken as a match.

The data of the study was analyzed by chi-square test, which revealed that shade selection using color difference formulas and graphic software was significantly more accurate than visual shade selection assisted by digital photography and conventional visual shade selection ( $P < 0.001$ ).

## Discussion

Consistent, reliable shade selection is necessary for any shade selection protocol in order to achieve a predictable esthetic outcome for a dental prosthesis. Since the digital spectrophotometer analysis is considered the gold standard in shade selection, the results of Group 1 were considered as the control group in the present study.<sup>3</sup>

The VITA 3D-Master shade guide was used for visual shade selection, since it offers high intrauser repeatability and has been proven successful at achieving an acceptable color match.<sup>9</sup> The low percentage of shade match among Group 2 samples can be attributed to the fact that selection with a shade guide is highly subjective and depends on different parameters.<sup>10-12</sup>

Visual shade selection assisted by digital photography on a computer offered significantly better results than conventional shade selection, in keeping with a 2005 study by Jarad et al, which found a computer monitor offered better color matching performance than visual shade matching (61% compared to 43%).<sup>6</sup> By contrast, Schropp found no significant difference between visual shade matching and shade selection with digital photographs viewed on a computer monitor.<sup>13</sup>

Digital color photographs allow dentists to compare shade to surrounding dentition and underlying substrates. Relative distributions of enamel staining, intensity of characterization, and different degrees of translucency and opacity within the incisal edge can be captured adequately. Black and white photographic images can provide a visual description of surface texture, as well as a value comparison.

The mathematical method of applying color difference formulas and graphic software was evaluated, and was superior to both visual shade matching and digital photographs, offering a more accurate lightness and hue.

Using graphic software analysis with color difference formulas and digital photography can be a viable alternative to

Table 1. Comparison of the number of positive and negative observations for shade selection of the 4 study groups ( $P < 0.001$ ).

Groups		Group 1	Group 2	Group 3	Group 4	Total observations
Shade selection	Positive Count	31	10	13	19	73
	(%)	100	32.3	41.9	61.3	58.9
	Negative Count	0	21	18	12	51
	(%)	0	67.7	58.1	38.7	41.1
Total observations	Count	31	31	31	31	124
	(%)	100	100	100	100	100

Table 2. Differences in the shade selection methods of the 4 study groups.

Group 1—Shade selection by spectrophotometer	Group 2—Visual shade selection	Group 3—Visual shade selection assisted by digital photography on a computer	Group 4—Shade selection with color difference formulas and computer software
Gold standard in shade selection	Most frequently used method for shade selection in dentistry	Has potential for use in shade determination	Color difference formula is a mathematical way of assessing and comparing 2 shades
Easy to use and learn		Standard cameras and camera settings not yet defined for dental photography	Software used to remove interferences such as glare, dark spots
Can provide single base shade and 3 separate shades for (gingival, middle, and incisal) thirds	Affected by many parameters such as eye fatigue, light source, and color blindness	Dental photographic devices expensive and not easily available	Calculation can be labor intensive.
Shade verification on restoration possible	Dependent on so many factors that artificially or naturally creating a perfect condition difficult to achieve	Images can be transferred electronically to the dental laboratory.	Using graphic software for color analysis requires training.
No computer required		Dental technician will have a better idea of tooth form, surface texture, translucency, and various hypoplastic defects.	Depends on software and the photograph, not the human eye, which can be affected by many factors
Does not provide shade map			
Edge-loss error		Differences in computer monitors (such as brightness level) can make shade selection difficult.	Standardization of this technique needed
Reproducibility on tooth surface			

digital spectrophotometry and colorimetry. Digital cameras, computers, and graphic software are becoming increasingly common in dental practice and laboratories, and this study indicates they are useful for accurate shade matching.

Dental students who had worked with both visual and digital tooth color determination systems found it significantly easier to determine tooth color with a digital system than with a visual system.<sup>14</sup> Shade matching that is based on digital imaging is convenient and less expensive than the use of spectrophotometers or colorimeters, and may provide the entire spectrum of color space for natural teeth. Additionally, digital imaging is recognized as an objective and efficient tool for communication with

a dental laboratory. In their 2010 study, Oh et al found a statistically significant difference in matching the tooth color using conventional visual shade selection, color analysis using digital photography, and color difference formulas and computer software, with graphic software deemed the most accurate selection method.<sup>15</sup> In another study, Vafaii et al concluded that shade selection by clinical observation of porcelain fused to metal crowns had a higher accuracy than digital image evaluation.<sup>16</sup>

The present study did not include intra-operative variability. In addition, there was no variation due to different cameras or different graphic software. Therefore, additional studies may be required. Manual shade selection using graphic

software was done with a color sample tool that measured a small area near the middle third of the tooth. Translucency, bleached shades, and the clinical and esthetic outcomes related to this technique have yet to be studied.

Although a spectrophotometer remains the most accurate determinant of shade selection, color difference formulas in combination with graphic software offer a relatively easy and quick alternative chairside technique.

### Summary

Among the groups tested, conventional visual shade selection had the lowest shade match when compared with the spectrophotometer reading. Visual shade

selection assisted by digital photography on a computer offered slightly more accurate and statistically significant results compared to conventional visual shade selection. Shade selection performed with digital photography and graphic software using color difference formulas had a better and statistically significant shade match compared to both conventional visual shade selection and visual shade selection assisted by digital photography.

### Author information

Dr. Prabhu is a senior lecturer, Department of Prosthodontics, Asa Memorial Dental College and Hospitals, Chengalpattu, Tamil Nadu, India. Dr. Ariga is a professor and head, Department of Prosthodontics, Saveetha Dental College and Hospitals, Chennai, Tamil Nadu, India. Dr. Philip is a senior lecturer, Department of Prosthodontics, Tagore Dental College and Hospitals, Chennai, Tamil Nadu, India.

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# Treatment of root perforations with resin ionomer cement and connective tissue graft: a case report

Leogenes M. Santiago, DDS, MSc ▪ Bruna de C. Farias, DDS, MSc ▪ Alessandra de A. T. Carvalho, DDS, MSc, PhD  
 Catia Maria Fonseca Guerra, DDS, MSc, PhD ▪ Renata Cimoës, DDS, MSc, PhD

The clinical practice of endodontic therapy is relatively common, especially in the anterior of the mouth, with easy access to cavities and in cases of mechanical debridement. However, problems such as perforation of the root canal can occur during treatment, and can cause periodontal tissue damage and esthetic problems. The treatment of root canal perforation consists of periodontal and endodontic therapy, as well as selecting the best material for perforation repair.

This is a case report of iatrogenic root perforation on an anterior tooth that required combined restorative, periodontal, surgical, and endodontic approaches. The case describes the use of a subepithelial

connective tissue graft (SCTG) on a resin ionomer-restored root surface for the treatment of root perforation and periodontal damage caused by an iatrogenic procedure, with a 12-month follow-up. This case report shows that SCTG can successfully treat root perforations associated with a resin ionomer-restored root surface.

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Key words: connective tissue, glass ionomer cement, root canal therapy

**R**oot perforation is defined as the mechanical or pathological communication between the root canal system and the periradicular tissues.<sup>1-3</sup> It is usually an undesirable complication that can occur during preparation of endodontic access cavities and mechanical debridement. Iatrogenic root perforations occur in approximately 2%-12% of endodontically-treated teeth.<sup>2</sup> These perforations can occur due to root resorption, but are most commonly the result of iatrogenic damage sustained during preparation of endodontic access cavities, canal orifice searches, root canal shaping, and/or post-space preparation.<sup>1,3</sup>

The major problem associated with root perforation is the potential development of inflammatory lesions with destruction of the adjacent periodontal tissues.<sup>1</sup> The most severe damage to periodontal tissues occurs when the perforations remain open to the oral cavity, or when there is an inadequate seal due to leakage of the restoration materials.<sup>2</sup>

The prognosis for a tooth-with-root-perforation depends foremost on the prevention or control of bacterial infection at the perforation site. However, it also depends on the perforation's location and size, time since occurrence, periodontal condition, and the material used for perforation repair.<sup>1,2,4</sup>

The location of the perforation is extremely important, because proximity to the gingival sulcus may lead to

endodontic-periodontal problems through contamination of the perforation with bacteria from the oral cavity through the sulcus.<sup>3</sup> If the perforation lies coronal of the crestal bone, it will be easy to treat and lead to a good prognosis. Perforations near the crestal bone, however, are susceptible to epithelial migration and rapid pocket formation; treatment of these have a low success rate.<sup>1,3,4</sup> The time factor relates to whether or not the wound site has become infected. Larger defects make creation of an effective seal more difficult and are associated with greater trauma to the adjacent tissues.<sup>1</sup>

The ideal material for treatment of radicular perforations should be biocompatible, non-absorbable, radiopaque, possess bacteriostatic or bactericidal effects, have good handling properties, and demonstrate adequate scalability.<sup>3-5</sup> Different materials have been used to seal perforations, including amalgam, calcium hydroxide, zinc oxide eugenol-based materials, resin ionomer cement, glass ionomer cements, MTA, super-EBA, and gutta percha.<sup>1,3-5</sup>

Resin ionomer has been used in the subgingival area as a perforation repair material due to its biocompatibility, adhesiveness to dentine, insolubility in oral fluids, good sealing properties, ability to produce cariostasis through the slow release of fluoride, low cure shrinkage, low coefficient of thermal expansion, lack of exotherm during setting, and radiopacity.<sup>3,5</sup>

This case report describes the use of a subepithelial connective tissue graft (SCTG) on a resin ionomer-restored anterior tooth root surface for treatment of a root perforation and the periodontal damage caused by this iatrogenic procedure, with a 12-month follow-up.

## Case report

A 26-year-old female patient was referred to the Department of Endodontics, ASCES Faculty, Caruaru, Brazil, for evaluation of a sinus tract that appeared above the gingival margin of tooth No. 9 after an initial appointment 15 days prior to root canal treatment. Clinical examination



Fig. 1. Clinical view showing a sinus tract on the attached gingival labia of tooth No. 9.

**Table. Clinical measurements at baseline and 12 months follow-up.**

Sites	Baseline			12 months		
	PD (mm)	CAL (mm)	Keratinized Tissue (mm)	PD (mm)	CAL (mm)	Keratinized Tissue (mm)
Tooth No. 9						
MB	2	0.5	3	2	0	4
B	11	N/A	2	1	0	5
DB	2	0.5	4	2	0	4
ML	2	0		2	0	
L	1	0		1	0	
DL	1	0		1	0	
Full mouth mean	1.5	0.5				

MB (mesiobuccal), B (midbuccal), DB (distobuccal), ML (mesiolingual), L (midlingual), DL (distolingual), PD (probing depth), CAL (clinical attachment loss)



Fig. 2. Initial radiograph of the root perforation.



Fig. 3. Radiograph of tooth immediately after root canal obturation.

showed a sinus tract on the labial-attached gingiva adjacent to tooth No. 9. A larger root perforation area of this tooth was also evident. The lesion characteristics were suggestive of root perforation during preparation of endodontic access to cavities. This lesion occurred between the cervical and middle height of the root, and included cortical bone and gingival tissue involvement (Fig. 1).

The patient showed mean values of probing depth (PD) of 1.5 mm, and clinical attachment loss (CAL) of 0.5 mm. The clinical measurements of tooth No. 9 at baseline were recorded and are presented in the Table.

After clinical and radiographic confirmation of root perforation (Fig. 2), repair was initiated. At the first appointment, the tooth was cleaned with saline solution and the root canal was irrigated with 1% sodium hypochlorite. The root canal was filled with calcium hydroxide paste and the root perforation was temporarily sealed with a zinc oxide eugenol-based material. In the second session, mechanical debridement with the progressive corona-apical instrumentation was performed and the root canal was then filled by lateral compaction of gutta percha (Fig. 3).

After local anesthesia, a full-thickness flap with vertical incisions extending beyond the mucogingival line was reflected to expose the root surface and the bone (Fig. 4). Excess gutta percha was removed, and acid etching was carried out with tetracycline



Fig. 4. Clinical view of the root perforation.



Fig. 5. Clinical image of resin ionomer application.



Fig. 6. The connective tissue graft used.

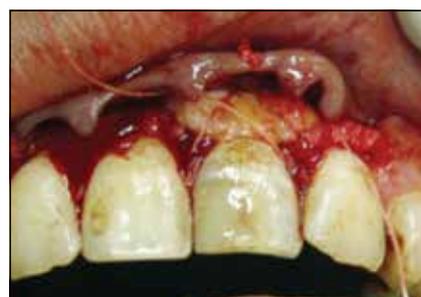


Fig. 7. SCTG sutured into the recipient area.

solution (50 mg tetracycline/saline) to remove surface contaminants and expose a fresh area of root surface to obtain a better perforation sealing. Resin ionomer was used to restore the root perforation (Fig. 5).

In order to obtain root coverage, augment the thickness area of gingival tissue, and create an acceptable gingival

contour, a connective tissue graft (CTG) was performed 7 days after the endodontic treatment and perforation sealing. The CTG was obtained from the palate, using the Langer and Langer technique (Fig. 6).<sup>6</sup> The graft was sutured into the recipient area using 4-0 polyglactin suture (Fig. 7). The pedicle flap was coronally



Fig. 8. Pedicle flaps sutures over SCTG and the resin ionomer-restored root perforation.



Fig. 9. Postoperative clinical view 2 weeks after perforation repair.



Fig. 10. Postoperative clinical view 12 months after perforation repair, showing resolution of the sinus tract.

positioned at the cementoamel junction to ensure maximum coverage of the SCTG underneath, and sutured with 4.0 silk sutures (Fig. 8).

The patient was prescribed 0.12% chlorhexidine mouthwash twice daily for 1 month, and an anti-inflammatory drug (Nimesulide, 100 mg) twice daily for 3 days. The sutures were removed 9 days after surgery. Postoperative follow-up controls were obtained at 2 weeks, and at 1, 3, 6, 9, and 12 months (Fig. 9 and 10).

The PD of the midbuccal site decreased from 11 mm (baseline) to 1 mm (12 months follow-up), and it was also followed by an additional gain of keratinized tissue from 2 mm (baseline) to 5 mm after 12 months (Table).

## Discussion

The prognosis of perforation repair procedures is closely related to the time elapsed since the creation of the perforation, the size of the perforation, and the site of perforation in relation to the level of crestal bone and epithelial attachment.<sup>1,2,4</sup> Adequacy of the restorative material, and the periodontal surgical technique, can also be contributing factors to the outcomes of perforation repair.<sup>1,2,4</sup>

Resin ionomer cements have demonstrated good responses in subgingival areas to treat root and furcation lesions and to restore resorption cavities.<sup>5,7,8</sup> These positive outcomes are related to resin ionomer cement's properties of biocompatibility, adhesiveness to dentine, insolubility in oral fluids, good sealing properties, ability to produce cariostasis through the slow release of fluoride, low

cure shrinkage, low coefficient of thermal expansion, lack of exotherm during setting, and radiopacity.<sup>3,5,8</sup>

Some studies have demonstrated the applicability of resin ionomer in subgingival areas, and excellent compatibility with periodontal tissues. Dragoo demonstrated histological evidence that both epithelium and connective tissue can adhere to the resin ionomer when placed in a subgingival environment.<sup>9</sup> Harris reported successful use of SCTG over a glass ionomer-restored root surface for the treatment of a cracked tooth.<sup>10</sup> Alkan et al observed a creeping attachment that occurred on a glass ionomer-restored root surface after a SCTG.<sup>5</sup> Santamaria et al reported in vivo studies that supported the applicability of resin ionomer for subgingival restorations and a positive response to periodontal tissue.<sup>11-14</sup>

In this case report, a surgical approach was necessary to obtain adequate access for treatment of the root perforation and periodontal damage caused by the iatrogenic procedure. SCTG was used to obtain root coverage, to augment the thickness area of gingival tissue, and to create an acceptable gingival contour at the perforation site. Use of this approach was supported by several studies that have shown positive responses to the SCTG on a resin ionomer.<sup>5,10,15</sup>

At the 12-month follow-up, the use of an SCTG on a resin ionomer-restored root surface was proven effective for treatment of the root perforation and periodontal damage caused by an iatrogenic procedure. Therefore, use of SCTG with resin ionomer restoration can provide adequate function and satisfactory long-term aesthetic outcomes.

## Conclusion

This case report shows that resin ionomer can be used to restore subgingival areas and to seal root perforations, with satisfactory biological and aesthetic results. The results also indicate that SCTG can be successfully performed for treatment of root perforations associated with a resin ionomer-restored root surface.

## Author information

Drs. Santiago and Farias are postdoctoral candidates, Federal University of Pernambuco, Recife, Brazil, where Dr. Carvalho is an associate professor, Department of Clinics and Preventive Dentistry, and Drs. Guerra and Cimoës are associate professors, Department of Prosthesis and Oral and Facial Surgery.

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# Green teeth in a premature infant following hemolytic jaundice

M. Rammal, DDS ▪ M. Meador, DMD ▪ M. Rodriguez, DMD ▪ B. Lish, DDS

Green staining of the dentition is a phenomenon associated with the deposition of bilirubin in the matrix of hard tissue during formation. This article presents a case of green teeth in a patient born 28 weeks premature with a medical history of hemolytic jaundice and grade IV intraventricular hemorrhage at birth.

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Key words: hyperbilirubinemia, jaundice, bilirubin, green teeth

**G**reen staining in the dental hard tissue is an uncommon condition associated with bilirubin (a degradation product of hemoglobin) deposition.<sup>1</sup> Intrinsic staining of the dentition occurs during odontogenesis, due to an alteration in the light transmitting properties of tooth structure. Several metabolic disorders, systemic syndromes, and well-documented systemic antibiotics (including tetracycline and ciprofloxacin) have been recognized as presenting an array of hues in hard tissue development.<sup>1-3</sup> Green staining has been reported in association with hemolytic jaundice, biliary atresia, neonatal hyperbilirubinemia, and cholestasis.<sup>4</sup> A 2003 survey by Lin et al studied children undergoing liver transplants and reported significant green staining of teeth and gingiva correlating to high levels of serum bilirubin.<sup>5</sup> Intrinsic staining from hyperbilirubinemia is a rare condition—to date only 50 cases of green staining have been reported in the dental literature.<sup>6</sup> Miller & Forrester were the first to conduct clinical studies that presented the earliest association between kernicterus or jaundice and intrinsic green staining of dentin and enamel hypoplasia in newborns.<sup>6</sup>

*Hyperbilirubinemia* is a condition that occurs when the serum bilirubin concentration is  $>1.5$  mg/100 mL. It was believed originally that bilirubin levels had to be  $>500$   $\mu\text{mol/L}$ , but cases of hyperbilirubinemia have been reported with bilirubin levels  $<200$   $\mu\text{mol/L}$ .<sup>6,7</sup> In cases of hyperbilirubinemia, serum bilirubin is deposited in the matrix formation of hard tissue, which remains discolored due to cessation of metabolic activity.<sup>1,6,8</sup>

A 2012 article by Battineni et al reported that extremely low birth weight was a predisposing risk factor for the development of green teeth in premature infants.<sup>4</sup> Green teeth were noted in 3 premature infants with a gestation range of 23-24 to 26-28 weeks, with birth weights from 400 to 840 g. In addition, these infants had a history of prolonged conjugated hyperbilirubinemia, originating in postnatal Week 3, and peaking in postnatal Week 8.<sup>4</sup> As green staining of the dentition is an unusual occurrence, this article presents a novel case of green primary teeth in a premature infant due to bilirubin deposition.

## Case report

A 16-month-old boy was brought to the clinic by his mother, with the chief complaint of discolored green teeth. The patient's medical history indicated birth at 28 weeks premature with a weight of 454 g. The patient had no known drug allergies and was currently taking adrenocorticotropic hormone (ACTH) and Topamax (Janssen Pharmaceuticals, Inc.) for epilepsy, and pyridoxine for vitamin B-6 deficiency.

These medications are not known to cause any intrinsic green staining of the dentition. His medical history at birth was significant for jaundice, respiratory distress, apnea of prematurity, pleural effusion, osteopenia of prematurity, hypotension, anemia, retinopathy of prematurity, grade IV intraventricular hemorrhage, and hydrocephalus. The patient was treated with a ventriculoperitoneal (VP) shunt placement due to hydrocephalus with multiple VP shunt revisions due to infection, ventriculitis, and meningitis. The patient also was diagnosed with spastic cerebral palsy, symptomatic generalized epilepsy, and global developmental delay. Normal bilirubin reference values range from 0.2-1.3 mg/dL; by contrast, the patient had a bilirubin level of 4.5 mg/dL at birth, which steadily increased to 21.8 mg/dL at 9 days after birth. Intraoral examination of the dentition showed no caries, with severe green discoloration of all erupted teeth, along with normal anatomy and texture (Figure). The chief complaint of the dentition's green discoloration is compatible with the complex medical history presented.



Figure. Green pigmentation in the primary dentition of a 16-month-old boy.

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## Discussion

When a patient has green discolored dentition, it is crucial for the dentist to have a thorough understanding of the etiology of the discoloration process, as understanding the cause and pathological process of the discoloration is invaluable for establishing a corrective treatment plan. In the present case, the discoloration of the patient's dentition was attributed to hemolytic jaundice at birth along with premature birth and possibly grade IV intraventricular hemorrhage. The measurement of bilirubin levels indicating hyperbilirubinemia at approximately 9 days after birth (with peak levels reaching 21.8 mg/dL) correlates with the period in development when primary teeth begin to calcify (that is, between 4 and 6 months *in utero*) and reach crown completion within the first year after birth.<sup>9,10</sup> According to Forrester & Miller, metabolic disturbances corresponding to the seventh month of intrauterine development would be expected to affect the incisors halfway through their development, but would only touch the tips of the canines and molars.<sup>11</sup> It was at this period in development that hyperbilirubinemia occurred in the present case, which led to green intrinsic staining in the dentition.

Among the pediatric population, staining of the dentition causes immense anxiety for both parents and children.

Management of pigmented dentition is mainly cosmetic and in most cases experts have advised doing nothing in the primary dentition.<sup>12</sup> In severe cases, clinicians can offer treatment options intended to allow the patient normal psychosocial development, including veneers, anterior composite crowns, or bleaching.<sup>7,12</sup>

## Summary

Tooth discoloration has a deleterious effect on the magnitude of a smile. Management of discolored teeth is a significant aspect of restorative dentistry. In the present case, a meticulous review of the literature and the patient's medical history were invaluable in deducing the etiology of the condition as hyperbilirubinemia, due to a history of hemolytic jaundice at birth, and a predisposing factor of being born 28 weeks premature with a birth weight of 454 g.

## Author information

Drs. Rammal, Meador, and Rodriguez are general practice residents, St. Luke's-Roosevelt Hospital, New York, where Dr. Lish is director of the Department of Dentistry.

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# Single tooth replacement utilizing implants in the esthetic zone: a case report

Nicholas Egbert, DDS, MDS, FACP ■ Swati Ahuja, BDS, MDS ■ Robert Brandt, DDS, MS ■ Vinay Jain, BDS, MDS  
Russell Wicks, DMD, MS

Replacing a single tooth with an implant has become a common dental procedure; however, careful evaluation is necessary before placing one in the esthetic zone. Thorough diagnosis and planning – including the use of transposed diagnostic casts and cone beam computed tomography scans – can help dentists predict the final esthetic result prior to treatment, and help inform the patient of the potential result prior to performing any irreversible therapy. In the present case, the primary concern was the presurgical location of the facial free gingival margin

(FGM) of the implant-supported crown, in relation to the adjacent teeth. Steps taken to correct the position of the facial FGM prior to implant placement led to a successful esthetic result.

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Key words: anterior, soft tissue, preservation

The utilization of dental implants for single tooth replacement has become one of the most common implant procedures in the U.S.<sup>1</sup> The advantages of single tooth implants include prevention of tilting and supraeruption of adjacent and opposing teeth, the conservation of adjacent tooth structure, and the psychological benefits of tooth replacement.<sup>1,2</sup> When a single tooth is deemed nonrestorable, extraction and socket preservation may be necessary, followed by replacement with an implant-supported single crown.<sup>3</sup>

## Implant placement in the esthetic zone

Placing a single implant in the anterior maxilla is a multifactorial process that requires attention to detail. When placing implants in this esthetic area, maintaining the bone architecture of the implant site and the accompanying gingival contours is vital.<sup>1,4</sup> In a 2001 article, Kois described 5 “diagnostic keys” to help the clinician determine the predictability of peri-implant esthetics: relative tooth position, periodontium form, periodontium biotype, tooth shape, and position of the osseous crest.<sup>5</sup> Optimal support and stability of the peri-implant soft and hard tissue depends on the correct 3-dimensional placement of the implant. In 2004, Buser et al suggested the following guidelines for implant placement: first, the mesio-distal distance between the adjacent teeth and the implant should not be less than 1 to 1.5 mm.<sup>6</sup> In addition, the facial implant shoulder should be positioned 1 mm palatal to the

point of emergence of the adjacent teeth for the proper emergence profile of the implant crown, and the top of the implant shoulder should be placed approximately 1 mm apical to the cemento-enamel junction (CEJ) of the facial surface of the contralateral tooth with no recession.<sup>6</sup>

## Preservation and maintenance of soft and hard tissues

The final location of the facial gingival margin and the preservation of the interdental papilla help to determine the esthetic outcome of an anterior implant. It is easier to maintain or create a papilla between an implant and a natural tooth than between 2 implants.<sup>7</sup> A 1992 study by Tarnow et al compared the presence or absence of papilla between 2 teeth, using the distance from the crest of the bone to the contact point between the teeth.<sup>8</sup> When a distance of  $\leq 5$  mm was achieved, the papilla filled the embrasure space 100% of the time. At 6 mm, the papilla filled the embrasure space 55% of the time; at 7 mm, the papilla filled the space 25% of the time. When an implant was placed adjacent to a natural tooth with  $< 5$  mm between the contact point and the crest of the bone, the papilla was maintained.<sup>8</sup> It appears that the key to maintaining the interdental papilla is the bone level of the adjacent tooth, rather than the interproximal bone level of the implant.<sup>4</sup>

Maintaining the facial gingival margin of an implant is more complicated. The facial gingival margin of an implant is related to the implant’s facial bone height and the

thickness and position of the FGM prior to removing the natural tooth.<sup>9</sup> The thin facial plate may be lost after the maxillary tooth is extracted. This amount of resorption/bone loss is directly related to facial contours and the amount of time a tooth has been absent.<sup>1</sup> The buccal bone crest is comprised of bundle bone, which resorbs more readily after tooth extraction than palatal bone, which has a cortical bone plate.<sup>4</sup> A 25% bone width reduction of the maxillary anterior ridge can occur within the first year of loss of a tooth.<sup>1</sup> To minimize the amount of facial bone resorption after implant placement, a labial bone thickness of 1.8 to 2 mm is desired.<sup>10</sup> Preserving the extraction site through bone grafting helps to maintain the vertical bone height, thus maintaining the soft tissue at the extraction site.<sup>11,12</sup> This preservation of the extraction site results in a healed site which is conducive to ideal implant placement and improved soft tissue contours.<sup>11,12</sup>

## Immediate placement of implants

It has been reported that the concurrent placement of implants into extraction sites and immediate provisionalization preserves gingival anatomy and prevents bone resorption.<sup>4</sup> In addition, the immediate placement of implants decreases the total treatment time and the number of surgeries.<sup>3,4</sup> However, it also has been reported that facial bone loss may occur despite the immediate placement of an implant.<sup>1</sup>

Three factors determine the feasibility of an immediate implant placement: the absence of acute noncontained infection,

the initial stability of the implant, and the nature of the bone present.<sup>13</sup> If a patient does not have bone of sufficient quantity and quality, then additional procedures (such as orthodontic forced eruption and hard/soft tissue grafting) may be required prior to implant placement.<sup>14-16</sup>

This case report presents the esthetic concerns involved in replacing a failing tooth No. 8. There was swelling and tenderness in the area; in addition, the facial gingival margin of the natural tooth had a 1 mm recession as a result of infection. As a result, it was decided to extract the tooth and prepare the site for implant placement at a later date.

### Case report

A 22-year-old female patient presented to the University of Tennessee College of Dentistry, Undergraduate Endodontic Clinic, for the evaluation of her tooth No. 8. The patient's chief complaint was pain and an inability to chew with tooth No. 8. According to the patient, tooth No. 8 had been a source of pain for 3 months. Swelling was noted in the area, with slight tenderness to percussion and palpation. The tooth had been avulsed and re-implanted 6 years earlier without endodontic therapy. A radiograph of the tooth revealed external root resorption with a periapical radiolucency (Fig. 1). In addition, a cone beam computed tomography (CBCT) scan was performed to further evaluate the tooth.

The CBCT scan revealed a large area of external resorption on the distolingual surface of the tooth and a small area on the buccal surface close to the tooth apex. The extent of the external root resorption was discussed with the patient and, at that time, the tooth was deemed unrestorable. The treatment options for replacing the missing tooth were discussed with the patient, including a removable partial denture, a fixed partial denture, and an implant crown. The patient agreed to the extraction of tooth No. 8 and replacement with an implant crown. The patient was referred to the Graduate Prosthodontic Clinic for extraction, implant placement, and restoration. Additional information was obtained during consultation. The patient had canine discclusion, with a 2 mm vertical overlap and a 1 mm horizontal overlap. The patient revealed a



Fig. 1. A periapical radiograph of tooth No. 8 revealing external root resorption.



Fig. 2. A pre-extraction photograph of maxillary anterior teeth. Note 1 mm recession of FGM at tooth No. 8.



Fig. 3. An occlusal view of tooth No. 8 area with putty in the extraction site.



Fig. 4. A provisional bridge is bonded in place after the extraction of tooth No. 8.

high smile line with 1 mm gingival recession on the facial aspect of tooth No. 8 (Fig. 2). The facial gingival contour of tooth No. 8 was highly scalloped with a thin biotype; the deepest facial periodontal probing was 3 mm. Following anesthesia, tooth No. 8 was extracted atraumatically, using forceps and periostomes. Care was taken not to damage the labial bone, and the socket site was examined to verify an intact buccal plate. The site was irrigated with saline and curetted. The socket was preserved utilizing Puros Demineralized Bone Matrix Putty (Zimmer Dental) (Fig. 3). A provisional undercontoured ovate pontic was fabricated with composite material (Integrity, DENTSPLY Caulk). Teeth No. 7 and 9 were etched with phosphoric acid (Ultra-Etch, Ultradent Products, Inc.) and bonding agent (Optibond Solo Plus, Kerr Corporation) was applied per

manufacturer's instructions. Using composite (Esthet-X, DENTSPLY Caulk), the highly polished pontic was bonded to teeth No. 7 and 9 (Fig. 4).

The implant site healed for 13 weeks. At the end of the healing period (and prior to the implant surgery), another CBCT scan was taken with a laboratory fabricated radiographic template in place to confirm good bone quality and quantity. The CBCT scan revealed that the bone thickness was adequate for placing an implant 4.5 mm in diameter. The distance between the nasal floor and the crest of the alveolar ridge measured 17 mm, while the distance between the implant platform and the cervical portion of the prosthetic tooth in the radiographic template measured 2.2 mm. The tissue over the implant site also was evaluated prior to surgery, and the attached tissue was determined to be adequate. The



Fig. 5. Photograph showing the implant after placement.



Fig. 6. Photograph showing the temporary abutment placed with markings for modifications.



Fig. 7. Photograph showing the temporary abutment after final adjustments, prior to fabrication of provisional tooth No. 8.

patient returned to the clinic for surgery. Anesthesia was administered to the attached tissue, providing hydrosopic dissection and hemostasis.

To identify the implant site specifically, it was decided to use the radiographic template as the surgical template. A 5 mm biopsy punch was used to remove tissue from over the implant site. The surgical template was reinserted and the drilling sequence was performed as follows. First, an Astra implant (DENTSPLY Implants) measuring 4.5 mm x 13 mm was placed, according to manufacturer's instructions (Fig. 5) and adequate primary stability was achieved (>50 Ncm). An Astra Tech TempDesign provisional abutment (DENTSPLY Implants) was screwed on the implant and marked for reduction (Fig. 6). Next, the provisional abutment was removed and a healing abutment placed to prevent tissue collapse while the provisional abutment was adjusted. The prepared provisional abutment was disinfected and evaluated intraorally for fit and adequate occlusal reduction (Fig. 7). Before the provisional was fabricated, the screw access was maintained by obturating the screw access hole with monophasic impression material (AquaSil VPS, DENTSPLY Caulk). A retraction cord (Ultrapak No. 2, Ultradent Products, Inc.) was placed gently around the abutment to prevent the provisional material from extending subgingivally. A laboratory-fabricated temporary was relined *in situ* with Integrity (shade B-1). The provisional was removed from the mouth and the subgingival contours of the provisional were modified with Esthet-X Flow (shade B-1)



Fig. 8. Side view of the provisional implant crown after final contouring and polishing.



Fig. 9. Anterior view of the provisional implant crown for tooth No. 8.

(Fig. 8). The provisional was adjusted, polished, and screwed into place by torquing the fixation screw to 15 Ncm (Fig. 9). The screw access hole was sealed with Systemcuring material (Ivoclar Vivadent, Inc.), universal shade. The occlusion on the provisional was evaluated and adjusted to remove any lateral interferences. After 6 months of healing, the provisional crown was removed and a fixture level impression was made. An Atlantis zirconium abutment (DENTSPLY Implants) was designed and fabricated. The final all-ceramic crown was fabricated to optimize the esthetics of the case as described by Gallucci et al.<sup>17</sup> The Atlantis abutment was placed and the final crown was tried in and evaluated for fit, function, and esthetics (Fig. 10). Custom staining was required to blend the crown with the adjacent teeth. Once the patient accepted the esthetics of the prosthesis, the Atlantis

abutment was torqued to 35 Ncm and the all-ceramic crown was cemented (GC Fuji Plus Cement, GC America, Inc.) (Fig. 11).

## Discussion

The following 5 diagnostic keys presented by Kois were integral to the planning of this case.<sup>5</sup>

### Relative tooth position

The failing tooth was evaluated in relation to the adjacent dentition in the apicocoronal, mesiodistal, and faciopalatal planes.<sup>5</sup> In this case, tooth No. 8 had an unfavorable facial gingival margin, positioned 1 mm more apical than the adjacent dentition. Without addressing the presurgical location of the facial gingival margin of tooth No. 8, the final location after healing could have been 3 mm more apical than the surrounding teeth.



Fig. 10. Anterior view of the placement of the Atlantis zirconium abutment.



Fig. 11. Facial view of the final restoration of implant-supported tooth No. 8.

### Form of the periodontium

The facial recession on tooth No. 8 was classified as highly scalloped with a facial pocket depth of 3 mm. An undercontoured bonded provisional was fabricated to prevent loss of papilla height, develop the emergence profile of the implant site, and support the soft tissue contours.<sup>15,18,19</sup> Undercontouring the provisional's facial and proximal contours promoted incisal migration of the soft tissue.<sup>19,20</sup> Care was taken to ensure the provisional pontic did not apply any pressure to the socket site during the healing phase, thus preventing additional apical migration of the facial gingival margin.

### Biotype of the periodontium

The gingival biotype for this patient was thin, thus fragile and more likely to recede. To minimize the anticipated recession, a flapless procedure (that is, a punch biopsy) was performed during implant placement, which minimized the loss of blood supply to the underlying bone and decreased the gingival recession.<sup>5</sup>

### Tooth shape

The shape of the patient's teeth was determined to be square tapering, which has an advantage over oval and triangular teeth. This shape minimizes the formation of black triangles due to long proximal contact, and provides more proximal support for the interproximal papilla.<sup>5</sup>

### Position of the osseous crest

The soft tissue contours depend on the location of the underlying osseous structure.<sup>15</sup> The position of the osseous crest is

an important predictor of the FGM after implant placement. Since the probing depths on the facial was 3 mm, one could expect recession of 1 mm in the area after surgery.<sup>5</sup>

Other diagnostic information was used to help predict and control the final esthetic results. The CBCT scan was used to verify the position of the prosthetic tooth and the location of the planned implant; and to predict the thickness of the labial bone. A 2000 study by Spray et al reported that the average labial bone thickness is 1.7 mm and the greatest amount of bone loss occurs when the labial thickness is less than 1 to 1.4 mm.<sup>10</sup> Very little bone loss occurs when the labial bone thickness is  $\geq 1.8$  mm.

In the present case, the implant to be used was superimposed virtually over the cross-section of the bone. The thickness of the bone was measured to be 1.7 mm, close enough to estimate that the amount of bone recession would be minimal. Previous studies have reported the ideal platform depth of 1 to 4 mm from the implant platform to the gingival margin or CEJ.<sup>1,10,21-23</sup> Utilizing CBCT, the distance from the implant platform to the cervical portion of the provisional pontic was gauged to be 2.2 mm. At the time of surgery and provisional placement, the FGM was approximately 4 mm from the implant platform. The FGM after placement of the provisional was more coronal than the FGM of tooth No. 9 (Fig. 5). With a predicted recession of 1 mm, the location of the FGM better approximated that of the adjacent teeth after healing.<sup>5</sup>

## Summary

Placing a single tooth implant in the esthetic zone is a challenging task. The literature has provided diagnostic aids for predicting the final esthetic results of a case. By applying these aids during the treatment planning stage, a dentist can accurately predict the esthetic outcome and inform the patient before the implants are placed. In the present case, the presurgical location of the facial FGM relative to adjacent teeth was the primary concern. Steps were taken prior to implant placement to correct the position of the facial FGM, leading to an acceptable esthetic result.

## Disclaimer

The authors have no financial, economic, commercial, and/or professional interests related to topics presented in this article.

## Author information

Dr. Egbert is in private practice in Salt Lake City, Utah. Drs. Ahuja and Jain are assistant professors, Department of Prosthodontics, University of Tennessee Health Science Center, College of Dentistry in Memphis, where Dr. Brandt is a professor and director, Advanced Education in General Dentistry program, and Dr. Wicks is a professor and chair.

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### Manufacturers

- DENTSPLY Caulk, Milford, DE  
800.532.2855, [www.dentsply.com](http://www.dentsply.com)
- DENTSPLY Implants, Waltham, MA  
800.531.3481, [www.dentsplyimplants.us](http://www.dentsplyimplants.us)
- GC America, Inc., Alsip, IL  
800.323.7063, [www.gcamerica.com](http://www.gcamerica.com)
- Ivoclar Vivadent, Inc., Amherst, NY  
800.533.6825, [ivoclarvivadent.us](http://ivoclarvivadent.us)
- Kerr Corporation, Orange, CA  
800.537.7123, [www.kerrdental.com](http://www.kerrdental.com)
- Ultradent Products, Inc., South Jordan, UT  
888.230.1420, [www.ultradent.com](http://www.ultradent.com)
- Zimmer Dental, Carlsbad, CA  
800.854.7019, [www.zimmer.com](http://www.zimmer.com)



**Exercise No. 332 Implants Subject Code 690**

The 15 questions for this exercise are based on the article, *Single tooth replacement utilizing implants in the esthetic zone: a case report*, on pages 30-34. 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:

- identify the keys to help determine peri-implant esthetics;
- recognize the need for ridge preservation following extraction; and
- understand how to optimize esthetics with anterior implants.

- The mesiodistal distance between an implant and an adjacent tooth should be no less than
  - 0.5 to 1.0 mm.
  - 1.0 to 1.5 mm.
  - 1.5 to 2.0 mm.
  - 2.0 to 2.5 mm.
- The key to maintaining the interdental papilla between an implant and an adjacent tooth is
  - a platform switching abutment.
  - the position of the CEJ relative to the platform.
  - micro-grooves on the implant collar.
  - the bone level of the adjacent tooth.
- The buccal bone crest adjacent to a tooth is composed of \_\_\_\_\_ bone.
  - bundle
  - cortical
  - woven
  - trabecular
- What is the labial bone thickness desired to minimize facial bone resorption after implant placement?
  - 0.8 to 1.0 mm
  - 1.0 to 1.2 mm
  - 1.4 to 1.6 mm
  - 1.8 to 2.0 mm
- Where was the implant platform positioned in this case at the time of surgery?
  - Even with the bone level
  - 1.8 mm coronal to the bone level
  - 2.0 mm apical to the CEJ of the adjacent tooth
  - 4.0 mm from the free gingival margin
- To create the proper emergence profile of an implant crown, the facial implant shoulder should be \_\_\_\_\_ to the point of emergence of the adjacent teeth.
  - 1 mm labial
  - 1 mm palatal
  - 2 mm labial
  - 3 mm apical
- Which of the following was found when evaluating the relative tooth position in this case?
  - An unfavorable mesiodistal relationship
  - A favorable linguoversion
  - An unfavorable facial gingival margin
  - An unfavorable labioversion
- The form of the peridontium in this case was
  - highly scalloped.
  - moderately scalloped.
  - slightly scalloped.
  - flat.
- The biotype in this case indicated that the patient was susceptible to
  - recession.
  - scarring.
  - hypertrophy.
  - mucocitis.
- The tooth shape in this case minimizes the risk for
  - facial recession.
  - black triangles.
  - inadequate bone.
  - gingival discoloration.
- According to Tarnow, the papilla filled the embrasure space 100% of the time when the distance between the contact point and the crest of the bone was less than or equal to \_\_\_\_\_ mm.
  - 8
  - 7
  - 6
  - 5
- It is easier to maintain or create a papilla between an implant and a natural tooth than between two implants. The position of the osseous crest is an important predictor of the FGM after implant placement.
  - Both statements are true.
  - The first statement is true; the second is false.
  - The first statement is false; the second is true.
  - Both statements are false.
- The maxillary anterior ridge may be reduced by what percentage during the first year after tooth loss?
  - 10
  - 25
  - 50
  - 75
- According to Spray, the average labial bone thickness is
  - 0.7 mm.
  - 1.7 mm.
  - 2.7 mm.
  - 3.7 mm.
- To help prevent papilla loss after extraction, the provisional in this case was
  - overcontoured.
  - undercontoured.
  - load bearing.
  - removable.

**Answer form is on page 80. Answers for this exercise must be received by June 30, 2014.**

# Unique CAD/CAM three-quarter crown restoration of a central incisor: a case report

Marvin B. Golberg, DDS ▪ Sharon C. Siegel, DDS, MS ▪ Niloufar Rezakani, DMD

Computer-aided design and computer-aided manufacturing (CAD/CAM) dentistry has been in use for more than 2 decades. Recent improvements in this technology have made CAD/CAM restorations a viable alternative for routine dental care. This technology is being taught in dental schools to prepare students for contemporary dental practice and is particularly useful in unique restorative situations that allow conservation of tooth structure. This case report describes the restoration of a central incisor that was previously restored with an unesthetic three-quarter gold crown. The tooth exhibited recurrent caries and an unaffected labial wall of supported enamel. A CAD/CAM three-quarter

crown was planned to conserve tooth structure. After preparation, the tooth was scanned for a CAD/CAM crown in order to fabricate a ceramic restoration, which was then milled and bonded, producing an esthetic result. Typically, in cases of esthetic enhancement, a labial laminate restoration is fabricated, but in this situation, a different approach was necessary to make a design for the lingual surface of an anterior tooth.

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Computer-aided design/computer-aided manufacturing (CAD/CAM) dentistry has made tremendous inroads in the way dentists can now conceptualize restorations.<sup>1</sup> Dentists should consider these technologies in their practices, especially since the number of dental technicians is significantly decreasing.<sup>2-5</sup>

CAD/CAM restorations were first introduced over 2 decades ago, but their accuracy did not meet the standards of cast restorations.<sup>6,7</sup> As the technology evolved, digital scanning and designing became more refined, which resulted in more accurate marginal adaptation.<sup>8-14</sup> CAD/CAM has now been developed to the point that dental schools are introducing this technology in their curriculum.<sup>15</sup> This paper presents a case report of the

replacement of an anterior defective gold three-quarter crown with a conservative, uniquely designed CAD/CAM restoration in a dental school environment. This was accomplished using a CAD/CAM system with in-office milling capabilities.<sup>16,17</sup>

## Case report

A 64-year-old male presented to the predoctoral clinic at the Nova Southeastern University, College of Dental Medicine, Florida, with the chief complaint of wanting to replace the gold filling on his front tooth with a “tooth-colored” one. Clinical examination revealed tooth No. 8 was restored with a three-quarter gold crown and had recurrent caries on the lingual, mesial, and distal surfaces (Fig. 1 and 2). The facial surface of the tooth had gingival

recession and a shallow, noncarious abfraction lesion. The periodontal health of the patient included a past history of recession and moderate periodontitis with nonbleeding sulcular depths of 2-3 mm (Fig. 3 and 4).

The patient’s occlusion was evaluated and presented with an Angle’s Class I canine and molar relationship on the right side, and a Class I canine relationship on the left side. There was 0.5 mm of overbite and 2 mm of overjet. The patient had a tendency to posture his mandible forward during the initial examination. The patient presented with generalized moderate wear and reported no parafunctional habits. There was no muscle tenderness upon palpation, nor was there any clicking or popping of the temporomandibular joints.



Fig. 1. Preoperative frontal view of tooth No. 8.



Fig 2. Preoperative maxillary occlusal view of tooth No. 8.

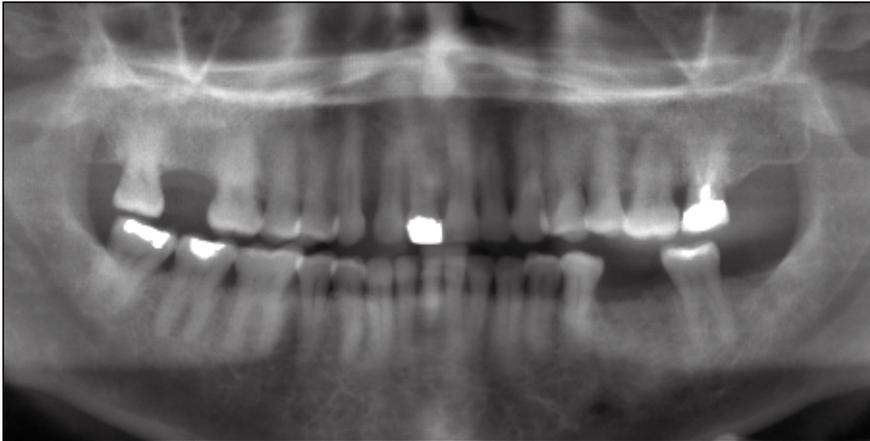


Fig. 3. Preoperative panoramic radiograph.



Fig. 4. Periapical radiograph of tooth No. 8.



Fig. 5. Occlusal view of crown preparation on tooth No. 8.



Fig. 6. Occlusal view of master cast for scanning.

Following periodontal therapy and re-evaluation, the restoration was removed. Caries was excavated and the remaining tooth was assessed to determine the most conservative and esthetic restoration that would preserve as much tooth structure as possible. Treating the tooth with a full crown would require removing the labial enamel, leaving only minimal dentin. The decision was made to use a bonded monolithic ceramic CAD/CAM three-quarter crown restoration on tooth No. 8 in order to preserve the labial enamel and remove as little tooth structure as possible.

The tooth was prepared for a lingual three-quarter crown with internally rounded shoulder margins and a flat incisal edge, following the CAD/CAM design protocol (Fig. 5). The preparation design included an internally rounded 1.2 mm lingual shoulder, mesial, and distal grooves to improve resistance and retention, a lingual reduction of 1.5 mm, and an incisal reduction of 2 mm. Diamond burs were used for the

tooth preparation (Two Stripper Brand Burs Diamond Bur Kit, Premier Products Co.).

A polyvinyl siloxane impression (Aquasil, DENTSPLY International) was made of the maxillary arch in a custom tray (Triad, DENTSPLY International). An alginate impression (Kromafaze, Dux Dental) was made of the mandibular arch in a stock tray (RimLock, DENTSPLY International). The impressions were poured with Type IV dental stone (Resin Rock, Whip Mix Corporation). A provisional restoration was fabricated for the patient utilizing a urethane dimethacrylate provisional material (Revotek, GC America, Inc.), and provisionally cemented (Temrex, Temrex Corp.).

The master cast for tooth No. 8 (Fig. 6) was powdered (CEREC, Optispray, Sirona Dental Systems, Inc.), and scanned using the CEREC Acquisition System (Sirona Dental Systems, Inc.). However, because the existing 3.85 CEREC Biogeneric software (Sirona Dental Systems, Inc.) at

the time of this study defaulted to a design of a labial veneer, this CAD/CAM restoration for a lingual veneer could not initially be designed (the latest 4.0 CEREC Biogeneric software can now produce the lingual veneer design).

In order to obtain the correct lingual veneer three-quarter crown design for the restoration in this study, the CAD/CAM manufacturer's *correlation mode* procedure was chosen. As such, there was no need for an interocclusal record or impression of the opposing arch since the lingual contour of the contralateral tooth is used as a template for the occlusion and anterior guidance, without consideration of the opposing arch.<sup>18</sup>

The digitized information was sent to the dental school's CEREC inLab milling machine (Sirona Dental Systems, Inc.) and the restoration was made utilizing Sirona CEREC VitaBlocs' Vita CE0124 28150 (VITA Zahnfabrik). The final milled restoration was seated



Fig. 7. Periapical radiograph of bonded CAD/CAM crown on tooth No. 8.



Fig. 8. Bonded crown on tooth No. 8.



Fig. 9. Occlusal view of bonded CAD/CAM crown on tooth No. 8.



Fig. 10. Frontal view post-cementation.

on the cast to ensure accuracy of fit and contour. Following a slight adjustment, the restoration was glazed (Vita Vacumat 30, VITA Zahnfabrik) with Empress Universal Glaze (Ivoclar Vivadent, Inc.).

After approval of the color try-in paste (Variolink II, Ivoclar Vivadent, Inc.), a yellow shade resin cement was selected and used under rubber dam isolation. The restoration was etched with 10% hydrofluoric acid for 60 seconds and thoroughly rinsed and dried with oil-free air. The restoration was silanated (Monobond Plus, Ivoclar Vivadent, Inc.) for 1 minute. The preparation was etched and scrubbed with 37.5% phosphoric acid for 15 seconds, then rinsed with copious water spray, and lightly air-dried. Bonding agent (Excite F DSC, Ivoclar Vivadent, Inc.) was applied to the tooth with gentle agitation for 10 seconds. The tooth was air dried for 3 seconds and the bonding agent cured for 20 seconds (Bluephase, Ivoclar Vivadent, Inc.)

The adhesive luting material (Variolink II, Ivoclar Vivadent, Inc.) was applied without catalyst to the intaglio surface of the restoration. The restoration was seated with firm pressure, allowing the excess resin luting cement to extrude. The curing light was waved over the restoration initially for 3 seconds and then the excess luting material was removed with an explorer and dental floss. Glycerin oxygen inhibitor gel (Liquid Strip, Ivoclar Vivadent, Inc.) was applied over the margins of the restoration to allow the complete setting of the luting cement. The margins were then completely cured for 40 seconds on each surface of the tooth.

After final curing, the margins were re-evaluated with an explorer and floss to ensure that no luting agent remained. Interocclusal contacts were marked with fine articulating paper (Accufilm I, Parkell, Inc.) and minor final adjustments were made intraorally. The margins and

occlusal surface of the restoration were polished with finishing burs and polishers (Dialite, Brasseler USA; Sof-Lex Discs, 3M ESPE).<sup>19</sup> A periapical radiograph was taken to confirm complete cement removal (Fig. 7). The patient accepted the final restoration as blending well with his natural dentition (Fig. 8-10). Figure 11 shows the restoration continuing to be functional and esthetic at a 2-year follow-up.

## Discussion

Conventional treatment planning in this case could have included a full metal-ceramic or all-ceramic restoration to replace the existing gold three-quarter crown after the removal of the recurrent caries in tooth No. 8. Examination of the patient revealed an intact facial enamel wall with recession and a gingival abfraction defect. Performing a full crown preparation on this tooth would have been very destructive, potentially requiring endodontic therapy,



Fig. 11. Frontal view of tooth No. 8 at 2-year follow-up.



Fig. 12. Frontal view at 2-year follow-up.

and possibly leading to an unesthetic result. Currently, a paradigm shift of bonding with resin cements in the dental industry is guiding more dentists toward the use of conservative preparation designs.<sup>20,21</sup> In this case, the manufacturer's correlation mode instructions were used to direct the CEREC software to design a lingual veneer or three-quarter crown restoration.<sup>22</sup>

This restoration was completed in order to preserve tooth structure, to maintain the natural enamel on the facial surface of the tooth, and to avoid a margin placed on cementum or dentin for an acceptable esthetic result. It was believed that this could be easily accomplished with a CAD/CAM restoration with a CEREC Vita Block to have a monolithic restoration with acceptable strength. The restoration was bonded to the tooth structure, and at a recall visit, the restoration was found to be in place successfully after 2 years, without debonding, chipping, or fracture.

The combination of the anterior tooth location, a difficult shade match, and the potential for a cement line close to the incisal edge posed challenges to obtaining an esthetic result. The patient was willing to accept a possible esthetic compromise, knowing the restoration was conservative and that tooth structure would be saved. The three-quarter crown was tested with a provisional restoration for 2 weeks to ensure that the restoration design would be successful, and it was maintained by the patient without dislodging or fracturing. The restoration was fabricated expeditiously with minimal expense in a dental school environment with a CEREC inLab system. At the 1- and 2-year follow-up evaluations, the patient demonstrated a more retruded mandibular position (Fig. 12).

CAD/CAM dentistry may be utilized to fabricate restorations that are durable and esthetically pleasing with superior fracture strength and excellent marginal adaptation. In the predoctoral dental clinic, time does not allow for preparation, scanning, designing, milling, and bonding in one appointment. Consequently, a cast is made from a traditional PVS impression in a custom tray. The student assists the faculty in the digital scanning of the cast along with the designing and milling of the restoration. This restoration is evaluated for marginal integrity, proper contours, and excellent occlusal and proximal contacts prior to bonding. The discussion between the student and faculty contributes to the educational process in understanding the laboratory aspect. Certainly, in a private dental office, an experienced practitioner could scan, design, mill, and bond the restoration in a single office visit.

Dental practitioners and dental school educators must evaluate their philosophy of restorative dentistry and consider CAD/CAM technology for the conservation of tooth structure and more bonding of select indirect restorations.<sup>23-25</sup> The use of this technology aids the dentist in obtaining an accurate, esthetic and acceptable restoration, which is accomplished expeditiously and economically, utilizing cutting edge digital protocols.

### Conclusion

This case report presents the replacement of an anterior three-quarter gold crown with a conservative, esthetic, CAD/CAM ceramic restoration in a dental school environment. A 2-year follow-up verified that the three-quarter restoration was functional and more esthetic than

the patient's original three-quarter gold crown. This unique case report is one example of a CAD/CAM bonded restoration that was creatively planned and designed to allow for the conservation of tooth structure and to support the philosophy of minimally invasive dentistry.

### Author information

Dr. Golberg is an assistant professor and director, CAD/CAM Dentistry, Nova Southeastern University, College of Dental Medicine, Fort Lauderdale, Florida, where Dr. Siegel is chair and professor, Prosthodontics section, and Dr. Rezakani, now in private practice, was a senior dental student at the time of the treatment.

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### Disclaimer

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## Manufacturers

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# Treatment of oral malodor and periodontal disease using an antibiotic rinse

Ken Southward, DDS, FAGD ▪ Anne Bosy, RDH, MEd, MSc

The purpose of this study was to determine the effectiveness of an antibiotic rinse preparation, containing metronidazole and nystatin, in decreasing oral malodor and periodontal disease for individuals whose chief complaint was halitosis. This topical approach to oral biofilm control, by proactively managing the most pathogenic bacteria, differs from the traditional approach of reactively treating the symptoms by attempting to reduce all oral bacteria. The late Dr. Loesche, University of Michigan, School of Dentistry, had previously described these different paradigms as the *specific plaque hypothesis* and the *non-specific plaque hypothesis*, respectively. Patients in this study were measured before and after treatment for volatile sulphur compounds using a portable sulphide monitor, a digital gas chromatograph, and organoleptic assessment. The presence of periodontal disease was determined by 6-point periodontal probing, to assess pocket depth and bleeding points. Of the 1000 patient charts sent electronically to the University of Michigan for analysis, 649 participants

were selected based on complete pre- and post-treatment data, and statistically analyzed by a statistician, who was an expert in case study analysis. The post-treatment reduction of oral malodor was 80% ( $P = 0.0001$ ). The difference in bleeding points pre- and post-treatment was 87% ( $P = 0.0001$ ). There was a decrease in the number of teeth with 6 and 7 mm pockets by 76% and teeth with 5 mm pockets decreased by 84% ( $P = 0.0001$ ). Treatment with the antibiotic rinse had a positive change in the periodontal status and breath odor of these patients. These data indicate that there is considerable advantage to the use of topical antibiotic rinses. A substantial decrease in both halitosis and periodontal disease markers can be achieved without the risk of the systemic effects of an oral antibiotic.

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Periodontal disease is a common affliction of adults, with most forms reflecting a tissue inflammatory response to bacterial accumulations on the teeth.<sup>1</sup> Mild forms of periodontal disease affect 75% of adults in North America, and more severe forms affect 20%-30% of adults.<sup>2</sup> Periodontal disease is a combination of an infection and an inflammatory condition associated with anaerobic Gram-negative bacteria.<sup>3</sup> Whereas gingivitis is an inflammation of the gingival tissue, periodontitis is a biofilm-associated inflammatory disease of the periodontium, and is a major cause of tooth loss.<sup>4</sup> The primary microbial factor contributing to this disease is a shift in the content of oral microflora, while the primary immunological factor is the destructive host's inflammatory response.<sup>4</sup> Periodontal pockets harbor a large assortment of pathogenic species with the most harmful ones being Gram-negative anaerobic rods.<sup>5,6</sup>

In 1999, Loesche described both the old and new approaches to periodontal disease, and proposed a different approach to periodontal disease.<sup>7</sup> Traditionally, periodontal care has been more surgically oriented, based on the *non-specific plaque hypothesis* of reducing all oral bacteria to minimize inflammatory risk and treat periodontal disease.<sup>7</sup> The new paradigm,

the *specific plaque hypothesis*, recognizes that only a certain few Gram-negative anaerobic pathogens cause periodontal disease, and that they can be controlled with specific antimicrobial agents.<sup>7</sup> Loesche wrote, *The contrast between the two paradigms can be succinctly stated as follows: The antimicrobial therapy reduces the cause, while the surgical therapy reduced the result of the periodontal infection.*<sup>7</sup> In theory, the specific plaque approach with antimicrobials would decrease risk, make treatment more effective, and be more economical. Furthermore, this new approach would have a beneficial impact on oral links to systemic diseases, such as cardiovascular disease and diabetes.

An ideal opportunity to assess Loesche's specific plaque theory occurred at the *Fresh Breath Clinic* (Toronto, Canada, [www.freshbreath.ca](http://www.freshbreath.ca)). This clinic offered no traditional services, such as prophylaxis, scaling, or surgery. Patients of the clinic were getting those services for some time from their regular dentist, but were dissatisfied enough with the ineffectiveness of the traditional approach to treat their halitosis that they sought an antimicrobial approach in addition to their regular care. Measuring the changes in periodontal reference points, such as bleeding on probing and pocket depths

between their initial visit and progressive appointments, would demonstrate the effectiveness or non-effectiveness of the antimicrobial approach. It is important to note that there was no change in the recall or traditional protocol with their regular dentist. In fact, the vast majority of patients did not want their dentist to know they were seeking additional care beyond their dentist's office.

Oral malodor, like periodontal disease, has been linked to the Gram-negative anaerobic pathogens that are implicated in periodontal disease, including *Porphyromonas gingivalis*, *Prevotella intermedia*, and *Fusobacterium nucleatum*.<sup>8,9</sup> These bacteria are capable of producing substantial levels of volatile sulfur compounds (VSCs).<sup>10,11</sup> VSCs are able to alter the permeability of gingival tissues, inducing an inflammatory response.<sup>12</sup> In addition, VSCs can penetrate deeply into other tissues and damage the epithelium, basement membrane, and underlying lamina propria.<sup>13</sup> Treatment of oral malodor as a result of VSC production should not be considered esthetic therapy, since these chemicals are toxic to periodontal tissues, even at low concentrations. Decreasing concentrations of VSCs may be a significant adjunct to periodontal therapy and in the prevention of periodontal disease.<sup>14</sup>

Species of oral bacteria are found as plankton (free-floating) bacteria, and in complex polymicrobial associations (biofilms) that exhibit a different structural and functional behavior than planktonic bacteria. In the past, most research was conducted on plankton bacteria, but researchers are now focused on the biofilm properties of dental plaque.<sup>15</sup> The formation of biofilm is a complex structural organization, that includes extracellular matrices of polysaccharides, proteins, lipids, nucleic acids, and other polymers with distinctive architecture, water channels, and available nutrients.<sup>16-18</sup> Biofilm provides a structure whereby different bacterial species are able to share nutrients. Waste matter from one species often becomes another species' food source.<sup>19</sup>

The symbiotic host-microbe relationship changes to a pathogenic one as the microbial community shifts to species that include *red cluster* bacteria, including *Treponema denticola*, *Porphyromonas gingivalis*, *Tannerella forsythia*, and others, such as *Prevotella intermedia*.<sup>20</sup> These pathogenic biofilms can avoid an immune system attack, as antibodies are unable to perforate the matrix, and phagocytes have difficulty in engulfing large clumps of biofilm fragments.<sup>21</sup> The inability of many antibiotics to penetrate the matrix offers further protection to the bacteria.<sup>21</sup>

The disease process progresses with few obvious signs. Some of the signs of periodontal disease may be bleeding when flossing, or a bad taste and/or breath odor, but these symptoms are not always recognized as indicators of periodontal infection.<sup>22</sup> These warning signs can sometimes be misinterpreted and assigned to one of the many other etiological factors that contribute to oral malodor.<sup>10,11,22</sup>

The aim of this study was to demonstrate that an oral antibiotic rinse consisting of metronidazole powder combined with nystatin is an effective treatment for both oral malodor and mild to moderate periodontal disease, and that there is a significant positive response by both conditions with this treatment. Prior to his recent passing, Loesche had the opportunity to analyze the results of this study, and witness its implications for a specific plaque approach to periodontal care.

**Table 1. Paired t test results showing changes in oral malodor post-treatment.**

	Before	After	Difference	DF	t value	P value
Halimeter	166.0 (639)	74.0 (576)	96.0 (571)	570	15.70	<0.0001
OCH <sub>2</sub> S	130.0 (342)	29.0 (421)	102.0 (220)	219	5.89	<0.0001
OCMM	36.0 (342)	8.0 (249)	28.0 (421)	420	5.09	<0.0001
Odor	2.6 (566)	0.5 (577)	2.1 (586)	565	36.56	<0.0001
pH tongue	7.3 (648)	6.8 (562)	0.5 (559)	588	12.92	<0.0001

Measurements are the mean at baseline, and after rinsing with the antibiotic rinse for 2 weeks, 2 times a day.  
 OCH<sub>2</sub>S = hydrogen sulfide measured on the OralChroma, OCMM = methyl mercaptan measured on the OralChroma,  
 Odor = organoleptic measurement of malodor (0-5)

**Table 2. Pearson correlation analysis of periodontal and malodor measurements.**

	Odor	Halimeter	OC-H <sub>2</sub> S	OC-MM	OCDMS	BOP
Odor	1.0000	0.40650	0.30455	0.28108	-0.04996	0.24137
		<.0001	<.0001	0.0001	0.4982	<.001
Halimeter	0.40650	1.0000	0.60101	0.48511	0.02457	0.14217
	<.0001		<.0001	<.0001	0.7440	0.0128
OCH <sub>2</sub> S	0.30455	0.60101	1.00000	0.54339	-0.02418	0.02527
	<.0001	<.0001		<.0001	0.7426	0.7407
OCMM	0.28108	0.48511	0.54339	1.00000	0.17579	0.01321
	<.0001	<.0001	<.0001		0.0158	0.8626
OCDMS	-0.04996	0.02457	-0.02418	0.17579	1.00000	-0.17338
	0.4982	0.7440	0.7426	0.0158		0.0221
BOP	0.24137	0.14217	0.02527	0.01321	-0.17338	1.00000
	<.0001	0.0128	0.7407	0.8626	0.0221	

Pearson correlation coefficients/prob > IRL under Ho:Rho=0. Data from appointment were analysed. Odor = whole mouth organoleptic scores; Halimeter = halimeter reading; OCH<sub>2</sub>S = Hydrogen sulfide reading on OralChroma; OCMM = Methyl mercaptan readings on OralChroma; OCDMS = dimethyldisulfide reading on OralChroma; BOP = bleeding on probing

**Materials and methods**

Individuals with self-diagnosed halitosis attended the Fresh Breath Clinic. Gender composition of the group was 60% women and 40% men, with an age range of 15 to 85. On the first appointment, patients were interviewed with respect to their health history, and bad breath or taste concerns. VSCs were measured using the Halimeter (Interscan Corporation) and the OralChroma (Abilit Corporation). Organoleptic measurement of the mouth and nose air was determined by experienced dental personnel, and scored

according to the standards for this procedure.<sup>23</sup> Tongue base, tongue dorsum, and proximal areas of the dentition were evaluated for odors. Biofilm samples from these areas were taken from each patient. A Gram stain analysis provided morphological information on the microorganisms present in the oral cavity. In addition, the microbiology of the teeth and tongue was tested with a BANA strip for red complex clusters. Six-point periodontal probing was used to assess pocket depth and bleeding points. Scaling and root planing was not available at this clinic, therefore patients

**Table 3. Paired t test results showing changes in number of pockets post-treatment.**

	Before	After	Difference	DF	t value	P value
BOP	20.5 (633)	3.2 (422)	18.8 (419)	418	17.05	<0.0001
4 mm pockets	4.9 (641)	1.3 (423)	4.0 (421)	420	9.68	<0.0001
5 mm pockets	1.4 (641)	0.2 (421)	1.2 (422)	421	7.48	<0.0001
6 mm pockets	0.4 (641)	0.1 (421)	0.3 (422)	421	3.98	<0.0001
7 mm pockets	0.2 (641)	0.02 (421)	0.2 (421)	421	3.36	<0.0001

Measurements are the mean at baseline and after rinsing with the antibiotic rinse for 2 weeks, 3 times a day. Difference refers to the change in the number of pockets per patient. Pocket depth and BOP determined by using 6-point probing.

**Table 4. Percent change in periodontal parameters and oral malodor measurements (n = 649).**

Test	Before	After	Difference
Bleeding on probing	19.98	2.68	87%
No. teeth with 4 mm pockets	4.86	1.24	79%
No. teeth with 5 mm pockets	1.22	0.15	84%
No. teeth with 6 mm pockets	0.38	0.09	76%
No. teeth with 7 mm pockets	0.17	0.04	76%
Odor Score	2.60	0.50	80%
<i>P</i> = 0.0001			

had no scaling done prior to treatment, although many of them were on a 3-month system of scaling at their dental office.

A sodium fluorescein 0.75% solution was used with a blue filtered mirror to evaluate the amount of biofilm present. Patients were instructed in oral care, with emphasis on techniques such as interdental cleaning and tongue scraping, which were seen as deficient. Patients with calculus and stain were advised to make an appointment with their dentist to have their teeth scaled.

Treatment was based on odor levels, the BANA test, and the results of the microbiology samples. Treatment initially consisted of rinsing with chlorhexidine 0.2% for 2 weeks, twice daily. Patients complained that, although their breath problems had decreased in intensity, some of the odor and bad taste remained, proving that the use of chlorhexidine alone was insufficient to completely reduce oral malodor.<sup>24</sup> To improve treatment response, systemic metronidazole and clindamycin were used to treat the patients, followed by the 0.2% chlorhexidine. However, systemic side effects and the use by patients of other pharmaceutical medications complicated this approach. Thus, another method had to be designed to successfully treat the chief complaint of halitosis.

The treatment chosen was a metronidazole-nystatin mixture that was used as a rinse. Sixteen tablets, each containing 250 mg of metronidazole (APO-metronidazole, Apotex Corp.), were crushed, the larger particles filtered

out, and the fine particles mixed with a nystatin suspension and 50 ml of water. Patients dispensed a “capful” (2 ml) of this mixture, swished and gargled for 30 seconds and expectorated the contents. Patients rinsed 3 times a day for 30 seconds each. Once per day, they flossed immediately after rinsing. After each rinse with antibiotic mixture, patients were to abstain from eating or drinking for 30 minutes. Although some patients found the rinse bitter and difficult to use, most were able to comply with the regimen. After 2 weeks of rinsing, patients returned to the clinic for an evaluation of treatment. Breath odor measurements and periodontal measurements were repeated, and compared with those taken at the initial appointment. Microbiology samples of the tongue base, tongue dorsum, and teeth were taken, analyzed, and compared with the pretreatment samples. Patients were then placed on chlorhexidine 0.2% for 2 more weeks, followed by routine rinsing with non-prescription mouthwashes that the patient selected.

To confirm the effectiveness of the antibiotic rinse, 1000 patient charts were sent electronically to the University of Michigan for analysis, of which 649 were selected based on complete pre- and post-treatment data, and then statistically analyzed by an expert in case study analysis.

## Results

The clinical results were encouraging, and patients provided positive feedback on the use of this protocol. Differences

in baseline and post-treatment measurements of breath odor were compared using a paired t test, and all reductions were significant (*P* < 0.0001) (Table 1). There was significant correlation between the organoleptic measurements, Halimeter readings, and OralChroma measurements of hydrogen sulfide and methyl mercaptan (Table 2). There was no significant correlation between dimethyl sulfide and the other measurements. Bleeding on probing correlated significantly with organoleptic measurements, but all other correlations were weak and insignificant.

The periodontal status of these patients showed significant change (Table 3). A substantial decrease from baseline is shown using a paired t test for bleeding on probing, and for the number of pockets ranging from 4-7 mm. These changes were significant (*P* < 0.0001). The percent decrease was substantial, with reductions in bleeding points at 87%, and a decrease in the number of teeth with 6 and 7 mm pockets by 76% (Table 4). The number of teeth with 5 mm pockets decreased by 84%, and those with 4 mm pockets decreased by 79%. Breath odor decreased by 79%, and bleeding points by 87%. All were highly significant (*P* < 0.0001).

## Discussion

The treatment with the antibiotic rinse had a positive change in the periodontal status of these patients, and resulted in substantial reduction in bleeding points and periodontal pockets. Breath odor

decreased dramatically, to the point that most patients felt that their breath had become “normal.” Vigorous rinsing, along with flossing to move particles into the sulcus was aided by the phenomenon called the *Venturi effect*. When particles enter the gingival sulcus and float over a pocket, the crevicular fluid drops, pulling the particle deeper into the pocket. The concentrated antibiotic particles can then act on the biofilm found at the base of these pockets. This would explain, in part, the change in pocket depth and the difference in the number of pockets, pre- and post-treatment.

Although scaling and root planing are considered the gold standard in the treatment of periodontal disease and have been used to decrease breath odor, recolonization of pathogens—along with the recurrence of the disease and breath odor—is common after scaling.<sup>25</sup> The use of antimicrobial therapy, along with scaling and root planing, is becoming conventional therapy. Antibiotics can be applied locally or administered systemically. However, since these organisms vary considerably in sensitivity to antibiotics, choosing the appropriate antimicrobial chemotherapy is challenging.<sup>6</sup> As an alternative, treatment aimed at suppressing inflammation or host modulation is also used. Most successful treatments address both the bacterial and inflammatory component of the condition.<sup>4</sup>

When antibiotics are taken orally, the efficacy of periodontal antibiotic therapy is determined by the antimicrobial spectrum and pharmacokinetic characteristics of the drug, and by local environmental factors.<sup>26,27</sup> This treatment is based on the belief that the antibiotic agent taken systemically can provide sufficient concentrations necessary to inhibit the pathogens.

Important considerations when choosing a treatment plan are the protection of pathogens by the extracellular matrix, the total bacterial load relative to maximum achievable antibiotic concentration, and extradental oral sites not affected by the therapy.<sup>28</sup> Several investigators found significant improvement of attachment levels when periodontitis was treated with systemic metronidazole.<sup>29-31</sup> The low minimum inhibitory concentration of metronidazole made it a useful chemotherapeutic agent for

treating anaerobic infections, such as *Porphyromonas gingivalis*.<sup>32</sup> Other studies showed improved clinical outcomes with the systemic use of metronidazole/amoxicillin, together with full mouth periodontal debridement.<sup>33,34</sup>

An advantage of systemic antibiotic therapy over topical application of an antimicrobial agent to a specific site is that systemic antibiotics enable the administration of a drug to multiple sites of disease activity, and may reduce pathogens colonizing on oral mucosa, the tongue, and tonsillar areas. The suppression or potential elimination of periodontal pathogens from the oral tissues is an advantage, in that the risk for future translocation of organisms and recolonization is reduced, thereby potentially reducing the risk for recurrent disease.<sup>35,36</sup>

There is, however, a considerable advantage to the use of topical antibiotic rinses. A topical application, in the form of a rinse with tiny particles of antibiotic, will coat all oral tissues, as well as the tonsillar areas, achieving an overall decrease in halitosis and periodontal disease markers without the risk of the systemic effects of an oral antibiotic.

## Conclusion

This study of cases from a halitosis clinic shows the potential of using antibiotic rinses to treat periodontal disease and oral malodor caused by oral pathogens. Since these cases were not intended initially to be a component of a study, and were analyzed because of the excellent clinical results that were achieved, a future controlled clinical study would be useful to determine if the results are due to a specific population, or if this can be extrapolated more generally, as a useful adjunct to the treatment of breath odors and periodontal disease.

The results of this study, however, are significant enough to warrant consideration of Loesche’s specific plaque approach as an initial therapy, or at least in conjunction with traditional nonspecific approaches, such as scaling and prophylaxis. More economical and effective periodontal care will enhance the chances of success of other restorative, esthetic, and/or implant dental procedures. It will also have a positive impact on oral/systemic disease links.

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## Disclaimer

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## Author information

Dr. Southward is a general dentist in Beamsville, Ontario, Canada. Ms. Bosy is senior vice president, Scientific Affairs, and a minority shareholder at Oravital, Inc., Toronto, Canada.

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## Manufacturers

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# The effect of a mouthrinse containing chlorine dioxide in the clinical reduction of volatile sulfur compounds

Leo Guimaraes Soares, DDS, PhD ▪ Roberto Luiz Guitolini, DDS, MS ▪ Sergio de Carvalho Weyne, DDS, PhD  
Marcio Eduardo Vieira Falabella, DDS, PhD ▪ Eduardo Muniz Barretto Tinoco, DDS, PhD ▪ Denise Gomes da Silva, DDS, PhD

This study sought to evaluate the clinical effect of a mouthrinse containing 0.3% chlorine dioxide (ClO<sub>2</sub>) in reducing oral volatile sulfur compounds (VSC). Halitosis was induced by L-cysteine in 11 volunteers, and 4 solutions were compared: a test solution containing 0.3% ClO<sub>2</sub>, 0.07% cetylpyridinium chloride (CPC), and 0.05% sodium fluoride; a placebo; a solution containing 0.05% CPC; and a control solution of 0.2% chlorhexidine gluconate (CHX). VSC levels were assessed using a Halimeter, and 6 measurements were made from baseline to 3 hours postrinse. The VSC reduction rate of the test mouthrinse was superior to

the placebo and the CPC solution. There was no difference between the test solution and the CHX solution in VSC reduction rates immediately postrinse, or at 2 and 3 hours postrinse; both solutions were statistically superior to the placebo and the CPC solution.

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Studies show a strong association between *halitosis* (defined as an unpleasant exhaled air odor) and biochemical reactions that take place in the oral cavity.<sup>1</sup> Halitosis is believed to originate within the oral cavity in most cases.<sup>2-5</sup> Such odors are attributed to the production of volatile sulfur compounds (VSC) in the posterior area of the tongue dorsum or in periodontal pockets.<sup>6,7</sup> Gram-negative anaerobic bacteria are responsible for the degradation of amino acids that result from the hydrolysis of peptides, salivary proteins, crevicular fluid, and oral tissue cells, producing, among other components, hydrogen sulfide (H<sub>2</sub>S).<sup>6-9</sup>

Initially described by Howe, halitosis can have a negative effect on individuals of all ages and social classes.<sup>10</sup> There are only a few studies evaluating the prevalence of oral malodor in the general population, with reported rates ranging from 22% to 50%.<sup>11</sup> In 2000, American patients in the US spent more than \$700 million on oral mouthrinses and \$625 million on mint tablets and other means to mask bad breath.<sup>12</sup>

Quirynen showed that mechanical cleaning and the use of mouthrinses can reduce halitosis levels.<sup>13</sup> Halitosis originating from the oral cavity has been attributed mainly to odorivectors based on VSCs, primarily H<sub>2</sub>S, methyl mercaptan (CH<sub>3</sub>SH), and dimethyl sulfide [(CH<sub>3</sub>)<sub>2</sub>S].<sup>14</sup> These gases derive mainly

from amino acid cleavage, such as cysteine originating from oral bacteria.<sup>12,15,16</sup>

Several studies have shown that the use of mouthrinses containing chlorine dioxide (ClO<sub>2</sub>) can result in low levels of VSC in what is commonly known as *morning breath*, improving a person's breath for up to 4 hours.<sup>17-20</sup> ClO<sub>2</sub> oxidizes VSCs directly to create nonmalodorous products and consumes amino acids that lead to VSCs.<sup>17</sup> ClO<sub>2</sub> has been used in mouthrinses for more than 30 years due to its safe and strong antibacterial action, and because it has no adverse side effects. Cetylpyridinium chloride (CPC) is another strong antibacterial agent that is used to control gingivitis and oral infections in general.<sup>21</sup> Sodium fluoride (NaF) solutions have a protective effect against dental caries and erosive and attritional enamel tooth wear.<sup>22</sup>

It could be assumed that mixing these particular compounds into a single solution would offer all of these properties in a single product. With that in mind, this clinical trial evaluated a solution containing 0.3% ClO<sub>2</sub>, 0.07% CPC, and 0.05% NaF, and its clinical effect in reducing VSCs that are strongly associated with halitosis.<sup>17</sup>

## Materials and methods

### Selection of participants

Sample size determination and pre-study power calculations were performed, and the estimated number of individuals needed

to reach a power of 0.8 within the chosen study design (4 groups) was 13. Therefore, 13 volunteers (5 males and 8 females), ranging in age from 25 to 48 (mean 32.1 ± 7.19 y), showing no clinical signs of periodontal disease, and with no previous history of systemic diseases or halitosis, were recruited at the School of Dentistry, Universidade UNIGRANRIO, Duque de Caxias, Brazil. Two volunteers did not show up for all measurements and were therefore excluded from the analysis. The study was approved by the Research Ethics Committee of Universidade UNIGRANRIO and all participants signed a written consent form.

### Study design

This study was a randomized, double-blind, crossover, placebo-controlled, clinical trial, with a washout period of at least 15 days between treatments. At the first treatment phase, a solution was given randomly to each participant. At the completion of the 4 treatment phases, all participants had used all solutions in a crossover manner, to minimize possible inter-individual variations.

### Solutions

Four different solutions were used in this study. Solution A was the test solution, containing 0.3% ClO<sub>2</sub>, 0.07% CPC, and 0.05% NaF (pH 7.4). Solution B was a placebo containing distilled water and inert dye. Solution C contained 0.05%

CPC. Solution D was a control containing 0.2% chlorhexidine gluconate (CHX). The solutions were in opaque bottles identified only by the letters A, B, C, and D.

### Experimental phase

All participants were instructed to refrain from any form of oral hygiene, any food or alcohol consumption, and the use of cosmetics with strong smell, for 12 hours before measurements. To induce formation of VSCs and consequently, halitosis, participants rinsed with 10 mL of 6 mM L-cysteine (pH 7.2) for 30 seconds.<sup>14,18,19</sup> Measurements of VSCs were made using a Halimeter (Interscan Corporation), previously calibrated to room temperature, using a protocol recommended by Rosenberg et al.<sup>23,24</sup> Three consecutive measurements were obtained for each individual at different time intervals, and means were calculated per manufacturer's recommendations. Six mean values were obtained for each participant for each solution: before the L-cysteine rinse, immediately after the L-cysteine rinse, immediately after rinsing with the assigned solution, and at 1 hour, 2 hours, and 3 hours postrinse.

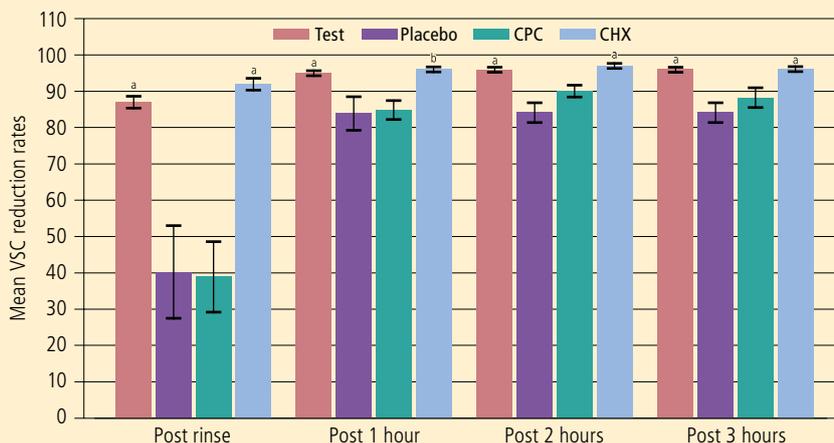
After each washout period of at least 15 days between treatments, each participant received a new solution in a crossover design. This procedure was repeated until all participants had used all 4 different solutions.

### Data analysis

The data collected from the different solutions were analyzed using the Kruskal-Wallis test for nonparametric data, with the Shapiro-Wilk test. When the Kruskal-Wallis test analysis revealed a value of  $P < 0.05$  (indicating a statistical difference between substances), the Student-Newman-Keuls test was used. The significance level was set at 0.05, and a statistical software package was used (Primer of Biostatistics 4.0, McGraw-Hill Professional).

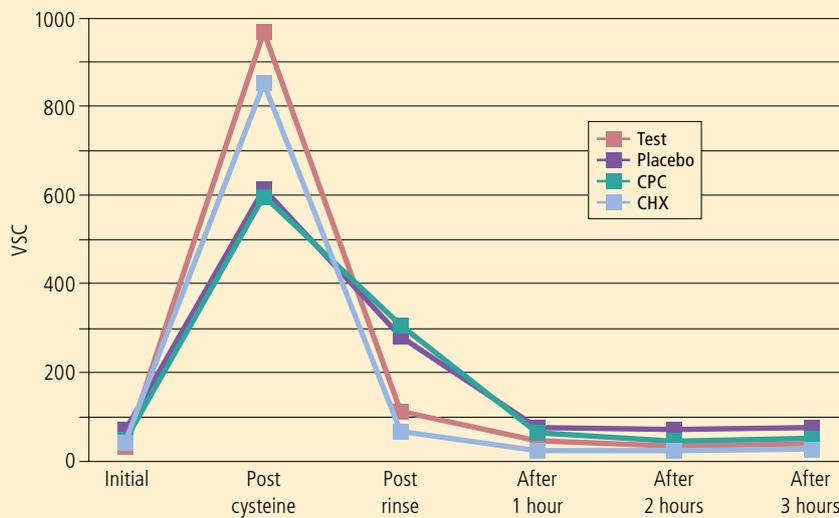
Mean VSC reduction rates were calculated for each solution and compared to each other. Reduction rate was calculated by subtracting immediately after using the L-cysteine rinse from the various postrinse values. Data normalization was performed by dividing postrinse values by those taken immediately after the L-cysteine rinse.

Chart 1. Mean reduction rates (% of baseline) in VSC levels for each solution at different time intervals.



<sup>a</sup> $P < 0.05$ . Test solution and CHX solution (control) significantly different from placebo and CPC solution.  
<sup>b</sup> $P < 0.05$ . CHX solution (control) significantly different from test solution.

Chart 2. Mean VSC levels (in parts per billion) for each solution at each time interval.



### Results

A statistically significant difference was found between the test solution and the solutions containing 0.05% CPC and placebo at all post-rinse intervals, except at the post-1 hour interval. CHX showed significantly higher reduction rates than the placebo and the 0.05% CPC solution at all intervals, and was superior to the test solution at the post-1 hour interval only (Chart 1). There was no difference in VSC

reduction rates between the test solution and the CHX solution immediately postrinse, after 2 hours and after 3 hours, both being statistically significantly superior to the placebo and the CPC solution throughout the study. There were no statistically significant differences in VSC levels between the groups after the L-cysteine challenge, indicating similar L-cysteine levels among all individuals. Chart 2 shows the mean VSC levels in parts per billion

for the different solutions over time, and the significant differences between them.

## Discussion

This study showed the clinical effectiveness of a solution containing 0.3% ClO<sub>2</sub>, 0.07% CPC, and 0.05% NaF to reduce oral VSCs. The authors' findings confirm similar results of previous studies that demonstrate ClO<sub>2</sub> efficacy for controlling halitosis and maintaining low VSC levels in morning breath.<sup>18-20</sup> Frascella et al demonstrated that ClO<sub>2</sub> has the ability to improve breath for up to 4.0 hours, while Silwood et al showed that products containing a chlorine anion and ClO<sub>2</sub> were effective, and a good therapeutic option in cases of halitosis.<sup>18,25</sup> In a 2000 study, Frascella et al used an organoleptic test and a sulfide monitor to test the neutralizing capacity of a solution containing 0.1% ClO<sub>2</sub>; the authors concluded that mouthrinse makes oral odor significantly more pleasant, reduces odor intensity, and still reduces VSC levels for at least 8 hours after use.<sup>19</sup> A 1997 study by Lynch et al used high resolution H NMR spectroscopy to determine that an oral mouthrinse containing a ClO<sub>2</sub> radical and a chlorite anion led to the oxidative consumption of cysteine and methionine anions, which are precursors of the VSCs responsible for halitosis.<sup>17</sup>

The cysteine-challenge protocol used in the present study has been proposed elsewhere in the literature, for the purpose of increasing VSC levels in healthy patients to verify whether the tested substances were effective in reducing them.<sup>21,26-31</sup> An experimental study involving humans who ingested ClO<sub>2</sub> and chlorite in drinking water found no adverse effects at doses as high as 24 mg/L (ClO<sub>2</sub>) and 5 mg/L (chlorite).<sup>17</sup> Two different epidemiological studies examined populations exposed to water that had been disinfected with ClO<sub>2</sub> and reported no hematological, teratogenic, toxic, or clinically adverse effects.<sup>21,32</sup>

The present study was a randomized, double-blind, cross-over, placebo-controlled, clinical trial with a washout period of 15 days between treatments. The randomized crossover design reduces variability and allows the same subjects to test different products. Each participant was given a solution randomly. At the end of treatment, all participants had used all treatments in a crossover manner to minimize possible inter-individual variations,

in keeping with the protocol established by Yaegaki et al in 2012.<sup>33</sup>

The use of subjective organoleptic evaluation is a common test, in which the patient breathes in proximity to the professional. Gas chromatography (GC) is the preferred method for the differential diagnosis of nonoral causes, and is considered the gold standard.<sup>6</sup> However, it is expensive and requires training and time for detection and measurements. There is no device available for routine use in clinics; however, the OralChroma (Abimedical Corporation) is a portable GC that detects and quantifies sulfur compounds. It is very small compared to the entire apparatus typically utilized in GC.<sup>6,13,14,26,30</sup>

In the present study, VSC was tested by using a sulphide monitor, demonstrated in the literature as offering superior reproducibility and sensitivity compared to the organoleptic test.<sup>16</sup> The sulphide monitor is noninvasive and more time-effective, and it has lower potential for cross-infection, greater portability, a relatively lower cost, and requires less skill to handle, compared to other GC devices.

CHX and CPC were chosen as controls in the present study, as they are among the most tested solutions in halitosis treatment.<sup>23,27,28</sup> Rosenberg et al used a 0.2% CHX solution (similar to the control used in the present study), and reported a 43% reduction in VSC levels.<sup>23</sup> Kleinberg & Codipilly demonstrated a product containing 0.12% CHX was effective against VSC.<sup>28</sup> Young et al showed in their study that CHX had a moderate effect against VSC, while CPC had no effect.<sup>27</sup> In the present study, CHX was effective in reducing VSC levels for up to 3 hours, while the CPC solution and the placebo demonstrated the same effects at all times. However, long-term use of CHX solutions are not recommended for controlling halitosis, as it can lead to strong extrinsic staining of the teeth and tongue.

Pilloni et al observed that CPC had an inhibitory effect on VSC production, while Carvalho et al reported that CPC had the lowest impact in VSC reduction among all products tested, which might be due to a lack of effective antibacterial activity.<sup>21,29</sup> Using the cysteine-challenge protocol, the test solution in the present study showed comparable results for ClO<sub>2</sub> and CHX in a short-term evaluation (up to 3 hours).

Although the differences between Solutions A, B, and C were statistically significant, their clinical significance has yet to be determined. In addition to the clinical reduction of VSC levels, using the ClO<sub>2</sub> solution long-term would avoid the staining effects induced by CHX-based solutions.

Shinada et al used a mouthwash with ClO<sub>2</sub> for 7 days in a randomized, double blind, crossover, placebo-controlled trial and reported decreases in morning breath (as measured by the organoleptic measurement) and in the concentrations of H<sub>2</sub>S, CH<sub>3</sub>SH, and (CH<sub>3</sub>)<sub>2</sub>S (as measured by gas chromatography); in addition, the ClO<sub>2</sub> mouthrinse appeared to be effective at reducing plaque on teeth, residual coating on the tongue, and the counts of *Fusobacterium nucleatum* in saliva.<sup>34</sup>

A 2011 study by Young & Jonski tested the clinical efficacy of brushing with toothpastes containing zinc (Zn) and found that zinc citrate with a PVM/MA copolymer reduced H<sub>2</sub>S by 48% compared to toothpaste without Zn; in addition, this toothpaste inhibited H<sub>2</sub>S formation following a cysteine challenge.<sup>35</sup> The authors concluded that this superior effect was most likely due to a higher concentration of Zn, combined with longer retention due to the presence of the PVM/MA copolymer. Both Zn toothpastes were more effective in inhibiting H<sub>2</sub>S formation compared to the Zn-free control toothpaste.<sup>35</sup>

Another crossover, double-blind clinical study compared a new mouthrinse for halitosis (0.3% Zn with 0.025% CHX) to 7 commercially available formulations.<sup>36</sup> The authors concluded that Zn and CHX at low concentrations demonstrated a remarkable efficacy in removing H<sub>2</sub>S. It has been hypothesized that the synergistic effect observed was caused by a coordinated attack on the soluble VSC, which involved CHX splitting the disulphide bonds, allowing Zn to bind to sulphur ions more efficiently, forming zinc sulphide, that is subsequently swallowed or expectorated.<sup>36</sup>

A 2010 study by Wilhelm et al compared a new mouthrinse containing amine fluoride/stannous fluoride (ASF), zinc lactate, and oral malodor counteractives to CHX, to determine the effect of each on oral malodor after a single use, and found that the newly formulated mouthrinse was as effective as the CHX mouthrinse after a single short-term use.<sup>37</sup>

In a retrospective study from February 2003 to February 2010, Zurcher & Filippi examined the medical histories of 465 patients, all of whom were reported to have suffered from bad breath.<sup>38</sup> In 82.7% of the patients (n = 373), true halitosis was diagnosed. Within this group, 96.2% (n = 359) had an oral cause. The majority of patients (94.5%; n = 426) had used a mouthrinse (62.9%, n = 268); however, only 11% (n = 47) had tried a tongue cleaner.<sup>38</sup> This data emphasizes the importance of a mouthrinse containing all of the effective compounds.

## Summary

Halitosis is a condition with a high social burden, and a high risk of undervaluation as an ancillary symptom. As a result, a clear algorithm must be drawn to carry out and optimize an appropriate critical pathway for patients affected by halitosis.<sup>39</sup> The results of the present study demonstrate that halitosis can be reduced successfully by the test mouthrinse containing 0.3% ClO<sub>2</sub>, 0.07% CPC, and 0.05% NaF, based on its effectiveness in reducing VSC levels for up to 3 hours, similar to CHX.

## Author information

Dr. Soares earned his doctorate in Dentistry at Universidade do Estado do Rio de Janeiro, Brazil, where Dr. Tinoco is an adjunct professor. Dr. Tinoco is also an adjunct professor at Universidade Unigranrio, Duque de Caxias, Brazil, where Drs. Silva and Falabella are adjunct professors, and Dr. Guaitolini is a master in Dentistry. Dr. Falabella is also an adjunct professor at Universidade Federal de Juiz de Fora, Brazil. Dr. Weyne is an adjunct professor at Universidade Estacio de Sa, Rio de Janeiro, Brazil.

## Disclaimer

The authors declare no conflict of interest or financial support related to this article.

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## Manufacturers

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# A clinically significant drug interaction between warfarin and amoxicillin resulting in persistent postoperative bleeding in a dental patient

Jason H. Goodchild, DMD ▪ Mark Donaldson, BSP, PHARMD, FASHP, FACHE

One of the few cases reported in the literature, this article reviews the case of a 66-year-old man who developed an elevated international normalized ratio and sustained clinically significant bleeding as a result of a drug-drug interaction between warfarin and amoxicillin. Given the popularity of these medications, it is surprising that these reports are not more commonplace, and there is a concern that the lack of reports may result in practitioners overlooking the significance of this possible complication. Although the mechanism for this interaction is not fully known, it is suspected that a decrease in vitamin K-producing gut flora,

with resulting vitamin K deficiency, is the most likely contributing factor. An objective causality assessment revealed that this adverse drug event, secondary to the warfarin and amoxicillin interaction, was probable.

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Meticulous monitoring of patients on warfarin therapy is important due to the drug's narrow therapeutic window. Subtherapeutic anticoagulation can increase the risk of clot formation, leading to an increased chance of stroke or venous thromboembolism, while supratherapeutic anticoagulation increases the risk for bleeding.<sup>1</sup> Additional problems, such as the need for frequent dose adjustments, and multiple drug and food interactions, make the use of vitamin K antagonists difficult for both physicians and patients.<sup>1-2</sup> Pharmacist-run clinics, where dose adjustments and multiple drug/food interactions can be closely monitored, have been shown to reduce costs, incidence of major bleeding events, hospitalizations, emergency visits, and thromboembolism, but in the absence of these specialists, dentists retain the primary responsibility of managing and coordinating appropriate dental treatment of patients who may also be taking warfarin.<sup>3-10</sup>

While guidelines exist to help the clinician manage the dental treatment of patients on anticoagulant therapy, there is an added level of complexity when the patient is taking or is prescribed additional medications.<sup>11-21</sup> Due to both the pharmacokinetic and pharmacodynamic characteristics of warfarin, a wide range of drugs have been linked to an increased risk of major bleeding in warfarin users, including warfarin-food and warfarin-herbal interactions.<sup>22-27</sup> Some of the most

commonly documented drug interactions that may be of concern to the dental prescriber include the ones between warfarin and various antibacterial agents.<sup>27</sup>

To determine the risks associated with particular drug interactions, clinical databases and clinical decision support

tools are available to help practitioners classify drug-drug interactions according to the level of risk they pose to the patient. The authors selected 3 clinical databases commonly used by dentists—Lexicomp (Wolters Kluwer), ePocrates (athenahealth, Inc.), and Micromedex (Truven Health

Table 1. Lexicomp risk rating definitions for drug-drug interactions.

Risk Rating	Action	Description
A	No known interaction	Data have not demonstrated either pharmacodynamic or pharmacokinetic interactions between the specified agents.
B	No action needed	Data demonstrate that the specified agents may interact with each other, but there is little to no evidence of clinical concern resulting from their concomitant use.
C	Monitor therapy	Data demonstrate that the specified agents may interact with each other in a clinically significant manner. The benefits of concomitant use of these 2 medications usually outweigh the risks. An appropriate monitoring plan should be implemented to identify potential negative effects. Dosage adjustments of 1 or both agents may be needed in a minority of patients.
D	Consider therapy modification	Data demonstrate that the 2 medications may interact with each other in a clinically significant manner. A patient-specific assessment must be conducted to determine whether the benefits of concomitant therapy outweigh the risks. Specific actions must be taken in order to realize the benefits and/or minimize the toxicity resulting from concomitant use of the agents. These actions may include aggressive monitoring, empiric dosage changes, choosing alternative agents.
X	Avoid combination	Data demonstrate that the specified agents may interact with each other in a clinically significant manner. The risks associated with concomitant use of these agents usually outweigh the benefits. These agents are generally considered contraindicated.

Analytics, Inc.)—to search for potential drug-drug interactions between commonly used antibiotics and warfarin. The Lexicomp grading system for drug-drug interactions is described in Table 1, where 5 risk categories are identified.<sup>28</sup> These 5 risk categories were designated: A (no known interaction), B (no action needed), C (monitor therapy), D (consider therapy modification) and X (avoid combination). Categories A and B are of academic—but not clinical—concern; whereas drug interactions in category C, D, or X always require the prescriber’s attention. A risk rating of C suggests monitoring therapy, as this combination of medication should be used only if the benefits outweigh the risks. Use of drugs in category D should be avoided, except in certain exceptional circumstances, and use of drugs in category X should be avoided. While Lexicomp reports the warfarin-amoxicillin interaction as category C, prescribers should not be lulled into complacency with the grade of this potential interaction. Given that both warfarin and amoxicillin are common medications, the true significance of this interaction may be more frequent and of greater concern than previously thought. Table 2 lists the potential interactions of commonly used antibiotics and warfarin as graded by the Lexicomp, ePocrates, and Micromedex database systems.

We present a case of warfarin-amoxicillin interaction that resulted in an elevated international normalized ratio (INR) and sustained clinically significant bleeding.

### Case report

A 66-year-old male presented for removal of his remaining maxillary teeth and immediate full-upper denture placement (Fig. 1). His medical history included atrial fibrillation, asthma, and human immunodeficiency virus. Current medications included acyclovir, albuterol, alfuzosin, alprazolam, bupropion, diltiazem, darunavir, Epcicom (abacavir and lamivudine) tablets, famotidine, fluticasone nasal spray, furosemide, omeprazole, ritonavir, rosuvastatin, Symbicort (budesonide and formoterol) oral inhaler, and warfarin (Coumadin, Bristol-Myers Squibb Company). He reported no known allergies to medications.

The patient reported no recent changes to medical status and no recent hospitalizations. His most recent laboratory values

**Table 2. Risk ratings for drug interactions between warfarin and antibiotics commonly prescribed in dentistry according to different databases.**

Medication	Drug Interaction Database		
	Lexicomp <sup>1</sup>	Micromedex <sup>2</sup>	ePocrates <sup>3</sup>
Amoxicillin	C	Major interaction	Monitor/modify treatment
Augmentin (Amoxicillin/Clavulanate Potassium)	C	Major interaction	Monitor/modify treatment
Azithromycin	C	Major interaction	Monitor/modify treatment
Cephalexin	None found	Major interaction	None found
Ciprofloxacin	C	Major interaction	Avoid/use alternative
Clindamycin	None found	None found	None found
Doxycycline	C	Moderate Interaction	Monitor/modify treatment
Erythromycin	C	Major interaction	Avoid/use Alternative
Levofloxacin	C	Major interaction	Monitor/modify treatment
Metronidazole	D	Major interaction	Avoid/use alternative
Penicillin V	C	Major interaction	None found
Tetracycline	C	Moderate interaction	Monitor/modify treatment

<sup>1</sup>Lexicomp: C—Monitor therapy. D—Consider therapy modification.

<sup>2</sup>Micromedex: *Major interaction*—The interaction may be life-threatening and/or require medical intervention to minimize or prevent serious adverse effects. *Moderate interaction*—The interaction may result in exacerbation of the patient’s condition and/or require an alteration in therapy.

<sup>3</sup>ePocrates: Drug interactions are organized according to clinical management (action required by the clinician) and utilize such categories as *Contraindicated*, *Avoid/use alternative*, *Monitor/modify Tx*, and *Caution advised*.

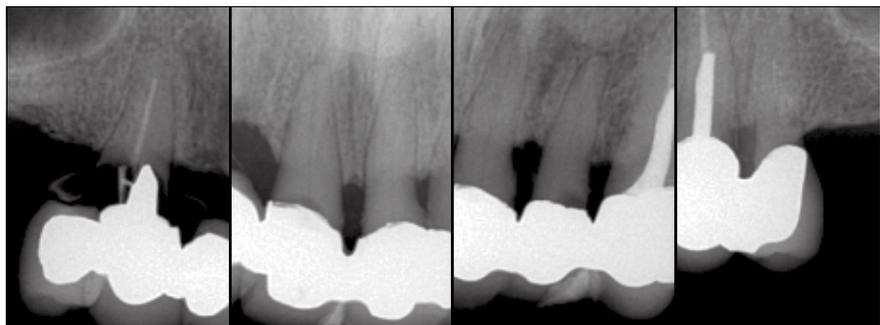


Fig. 1. Radiographs of 66-year-old patient prior to extractions (teeth No. 6, 8-12).

(within 1 month) were all within normal limits: CD4 was 627 cells/mm<sup>3</sup> (normal range 500-1500 cells/mm<sup>3</sup>), and the viral load was undetectable (<50 copies/mL). The patient’s warfarin dose, which had been stable for several years, was 7.5 mg per day, and his INR was 2.8 measured 1 day before the planned dental procedure. His blood pressure and pulse at the

start of the dental procedure was 100/66 mmHg and 87 beats/minute, respectively.

The patient was administered 4 capsules of 4% articaine with 1:100,000 epinephrine (272 mg articaine and 0.12 mg epinephrine). The remaining maxillary teeth were extracted without complication (teeth No. 6 and 8-12) and hemostasis was achieved with Gelfoam (Pfizer, Inc.),



Fig. 2. Clinical appearance of the extraction sites 1 week after surgery.



Fig. 3. Clinical appearance of the extraction sites 3 weeks after surgery.

3-0 interrupted sutures, and pressure. The immediate maxillary complete denture was relined with Hydrocast (Sultan Healthcare), and delivered. The patient tolerated the procedure without incident and was released with normal ambulation. A prescription for Percocet (oxycodone and acetaminophen) 5/325 x 15 tabs was written with instructions to take 1 or 2 tablets every 6 hours as needed for pain. The patient later reported that this prescription was never filled, as the level of pain never became intolerable.

The next day the patient returned to the office with a complaint of continuous bleeding from the extraction sockets. An intraoral exam revealed mild to moderate oozing from extraction sites No. 11 and 12. The gingiva in the area was erythematous and edematous, with slight evidence of purulent discharge. No other extraction sites appeared to be bleeding and all sutures were intact. The patient reported not being able to wear the immediate maxillary denture because of poor retention and persistent bleeding. One carpule of 4% articaine with 1:100,000 epinephrine (68 mg articaine, 0.031 mg epinephrine) was administered via infiltration and extraction sites No. 11 and 12 were resutured with 3-0 chromic gut. Hemostasis was achieved after biting pressure. The patient was given instructions to refrain from wearing the maxillary denture until healing was reassessed at a 1-week follow-up appointment. He was also prescribed Amoxil 500 mg (amoxicillin) (GlaxoSmithKline USA) to be taken 3 times/day for the next 7 days. At the

1-week postoperative visit, the patient again complained of bleeding from the extraction sites, however, he did note that it was less frequent and easily controlled with biting pressure. Upon intraoral examination, the extraction sites appeared to be healing nicely but evidence of recent bleeding and clot formation were obvious (specifically around the area of extraction site No. 6) (Fig. 2).

The patient was seen again 3 weeks post-extraction and reported that he was no longer experiencing any bleeding from the extraction sites, although he did admit that up until the “last few days” he still had oozing from the sites. Upon examination, all sites appeared to be healing normally and all sutures had dissolved (Fig. 3). The patient reported that since the last dental visit, his INR had been tested twice, giving readings of 5.8 (6 days after surgery and after 5 days of amoxicillin treatment), and then 2.0 (20 days after surgery and 12 days after discontinuing amoxicillin). The patient confirmed that, except for taking amoxicillin following the dental extractions, there were no other changes to his medical history or medication regimen, or his diet, both in the week leading up to his initial appointment, and in the 3 weeks following his procedure.

### Discussion

Warfarin is a vitamin K antagonist, which exerts its anticoagulant effect by interfering with the vitamin K conversion cycle.<sup>29</sup> The vitamin K conversion cycle adds the appropriate number of carboxyl groups to activate biologically active coagulation factors. By antagonizing the activity of the

reductase enzyme in the cycle, there is a reduced production of carboxyl groups, resulting in only partially carboxylated or completely decarboxylated vitamin K-dependent clotting factors (II, VII, IX, X) with a reduced procoagulant activity.<sup>29,30</sup> Warfarin is primarily indicated for the following conditions: prophylaxis and treatment of venous thrombosis and its extension, pulmonary embolism, prophylaxis, and treatment of thromboembolic complications associated with atrial fibrillation and/or cardiac valve replacement, and reduction in the risk of death, recurrent myocardial infarction, and thromboembolic events, such as stroke, or systemic embolization after myocardial infarction.<sup>31</sup>

The practice of dentistry is not contraindicated in patients receiving warfarin. In fact, current evidence supports the routine treatment of dental patients without interruption of warfarin therapy, provided the INR is <3.5.<sup>15-20</sup> For invasive dental procedures that may cause significant bleeding (such as full-mouth extractions, surgical extractions, extensive flap surgery), alteration or interruption of warfarin therapy should be considered in conjunction with the patient's physician. In these cases, an INR closer to the normal range of 1-1.5 is recommended. In 2008, Garcia et al determined that if the interruption of warfarin therapy is limited to 5 days or less, the risk of thromboembolism can be minimized.<sup>32</sup> Whenever possible, dentists should use local adjunctive measures to help establish hemostasis and promote clot formation; these may include sutures, stents, gelatin sponges, microfibrillar collagen, and topical

thrombin.<sup>33</sup> For patients who have an INR >3.5, elective dental procedures should be postponed and consultation with the patient's physician should be focused on possible INR lowering.<sup>15,18</sup> For patients who present with an INR >3.5 and need urgent treatment or cannot tolerate a lower INR as per the physician, the patient should be rendered palliative care and referred to a hospital-based or outpatient-based dental clinic.<sup>15,18</sup>

The primary mechanisms by which antibiotic medications are believed to interact with warfarin and increase the risk of bleeding are the disruption of intestinal flora that synthesize vitamin K and the inhibition of cytochrome p450 isoenzyme which metabolizes warfarin.<sup>34-37</sup> Interactions between warfarin and specific antibiotic agents have been widely assessed, primarily through case reports, case series studies, pharmacokinetic studies, and 3 population-based studies.<sup>34,38-47</sup> Based on these investigations, macrolides, metronidazole, quinolones, sulfonamides, and azole antifungals are thought to carry the highest risk of warfarin toxicity, whereas amoxicillin, cephalixin, and clindamycin are believed to have a more modest risk.<sup>41,47,48</sup> For these reasons, our initial differential diagnosis did not consider amoxicillin as the causative interacting agent with warfarin, however, with further research it became apparent that the sustained clinically-significant bleeding was most likely the result of a drug-drug interaction between warfarin and amoxicillin. This patient was closely followed, and in constant communication with one of the authors. The patient was instructed to use biting pressure to stop bleeding, but he was also counseled to seek immediate medical assistance if bleeding significantly worsened or became uncontrollable.

Several studies have reported that interactions between warfarin and antibiotic agents may result in increased INRs.<sup>27,41,43,48-50</sup> As a result, frequent monitoring of INR has been recommended for patients who are concurrently taking warfarin and antibiotic agents.<sup>41,47,49</sup> Given that inhibition of vitamin K synthesis by alteration of gut flora or inhibition of cytochrome P450 enzymes can lead to an increased INR, and therefore increased risk of bleeding within a 1-2 week period, a prudent strategy is to

closely follow the patient clinically and to monitor the patient's INR within a week of initiating antibiotic therapy.<sup>41,45</sup> More frequent monitoring should be considered for patients at higher risk for bleeding. In most cases, dose reductions of the antibiotic are not indicated for 2 reasons. First, subtherapeutic dosing of antibiotics may lead to inadequate blood levels of the drug, potentially causing the antibiotic to be less effective and possibly leading to bacterial resistance. Second, since warfarin-antibiotic interactions are not fully understood and the impact on INR cannot be predictably quantified, it is recommended that usual antibiotic doses be used, and the patient's INR be monitored postoperatively.<sup>45</sup>

Clinical databases and clinical decision support tools exist to aid the practitioner attempting to ascertain the risk versus benefit of a planned prescription, and any potential drug-drug interaction with medications the patient is currently taking. Additionally, aside from filtering the available research on a potential drug-drug interaction, clinical databases provide a quick source of information for providers seeking to avoid or minimize interactions and select the safest clinically appropriate medications. Of the databases used, Lexicomp and ePocrates are congruent with their risk classification of the warfarin-amoxicillin interaction; both recommend practitioners monitor therapy and consider modifying treatment. Only Micromedex considered this interaction to be "major." Indeed, even Lexicomp's language to describe this interaction downplays amoxicillin significance as compared to other penicillins, stating: *Penicillin antibiotics with a broader spectrum of activity (especially including those with a concurrent beta-lactamase inhibitor) may be most likely to cause a significant interaction.*<sup>28</sup>

According to the three clinical databases searched, the antibiotic clindamycin appears to be the safest to use when the patient is also taking warfarin. However, one case report exists where a patient taking warfarin was administered clindamycin following a dental extraction.<sup>51</sup> The patient subsequently experienced a significant increase in their INR which precipitated an emergency room visit to control the bleeding.

## Conclusion

An increased INR secondary to warfarin interactions with various antibacterial agents is a known phenomenon. An awareness of the potential for increases in INR following concomitant usage of antibiotics is essential for the dental practitioner. Appropriate monitoring is required to assess INR levels and prevent bleeding complications postoperatively. We report on one such case involving the interaction between warfarin and amoxicillin, which resulted in an elevated INR and sustained clinically significant bleeding.

## Author information

Dr. Goodchild is a clinical associate professor, Department of Oral Medicine, School of Dental Medicine, University of Pennsylvania, Philadelphia. He also is a clinical assistant professor, Division of Oral Diagnosis, Department of Diagnostic Sciences, New Jersey Dental School, University of Medicine and Dentistry of New Jersey, Newark, and is in private practice in Havertown, Pennsylvania. Dr. Donaldson is the director of Pharmacy Services, Kalispell Regional Medical Center, Montana. He also is a clinical professor, Skaggs School of Pharmacy, University of Montana, Missoula, and a clinical assistant professor, School of Dentistry, Oregon Health & Sciences University, Portland.

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## Manufacturers

athenahealth, Inc., Watertown, MA  
800.981.5084, [www.athenahealth.com](http://www.athenahealth.com)

Bristol-Myers Squibb Company, New York, NY  
800.332.2056, [www.bms.com](http://www.bms.com)

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Sultan Healthcare, Hackensack, NJ  
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# Effect of pH values of two bleaching gels on enamel microhardness

Natalia Costa Araujo, PhD ▪ Manuella Uilmann Silva da Costa Soares, PhD ▪ Marcela Maria Nery, MD  
Wagno da Silva Sales ▪ Marleny Elizabeth Martinez Gerbi, PhD

This study evaluated the influence of bleaching gel pH and the effect of remineralizing gels after bleaching in different time intervals. Sixty bovine incisors were divided into 2 groups (n = 30). Group 1 was bleached with a 35% hydrogen peroxide (HP) acid gel and Group 2 was bleached with a 35% HP neutral gel. Each group was then divided into 3 subgroups (n = 10) according to the postbleaching treatment used: storage in artificial saliva, application of a fluoride gel, or application of a gel consisting of fluoride, potassium nitrate, and nanostructured calcium phosphate. Specimens were stored in artificial saliva, and enamel microhardness was evaluated at 24 hours and 15 days postbleaching. Vickers microhardness data were analyzed by means of 2-way ANOVA, with repeated measurements and Bonferroni's post-hoc test.

Twenty-four hours after bleaching, no significant differences were found between the bleaching gels. At 15 days postbleaching, Group 2

samples demonstrated a significant reduction in microhardness. No significant differences were found between the remineralizing gels, though all of the postbleaching treatments after the use of 35% HP neutral gel were able to re-establish baseline microhardness. It was concluded that neutral bleaching gel significantly reduced enamel microhardness 15 days after bleaching and that the use of remineralizing gels did not significantly enhance the microhardness of bleached enamel. However, in clinical situations, the acquired enamel pellicle protects tooth surfaces, and postbleaching, decalcified enamel would undergo recalcification. This study indicates that it is important to consider the bleaching agent's pH and composition when treating patients with reduced salivary secretion.

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Patient demand for improved esthetics has increased the demand for tooth bleaching. The development of high-concentration hydrogen peroxide (HP)-based bleaching gels have made in-office bleaching procedures possible.<sup>1</sup>

Bleaching results from reduced oxidation caused by HP decomposing into free radicals such as oxygen and perhydroxyl. Because the last layer lacks an electron, these free radicals are extremely electrophilic and diffuse throughout the enamel and dentin matrix, attacking the macromolecules of pigments and thus acquiring stability. The intrinsic pigments (consisting of highly-unsaturated organic macromolecules) are transformed into smaller, lighter, and less complex molecules.<sup>2</sup>

A significant advantage to using in-office bleaching is obtaining immediate results without requiring patient compliance. However, bleached hydroxyapatite can lead to demineralization and loss of calcium.<sup>3,4</sup> Studies that investigate external bleaching therapies often test for microhardness, which is related to the mineral content of the tooth.<sup>5</sup>

Although the efficacy of bleaching agents has been reported in the literature, several studies have reported decreased microhardness in bleached enamel.<sup>6-10</sup> However, two 2004 studies reported no evidence of

deleterious effects on enamel after applying high concentrations of HP.<sup>11,12</sup> There is still debate as to whether these agents could adversely affect dental hard tissues.

The gel component that contains HP has an acidic pH in most cases because peroxide decomposition is reduced in an acidic environment; this makes the gel component stable for storage. Bleaching agents that are more alkaline have reduced expiry dates, which is the main reason why these materials have an acid pH. It appeared that the main function of the activating gel component is to increase the pH of the mixed gel, thereby increasing the decomposition rate of peroxide and the formation of bleaching active radicals.<sup>2</sup>

Both the pH of bleaching materials and the chemical action of HP can alter the organic matrix of enamel.<sup>11</sup> The strong oxidizing effect of HP on the organic matrix of teeth plays a predominant role in the alterations observed after bleaching, such as a decrease in enamel and dentin microhardness. These alterations can be increased by a bleaching agent with a low pH.<sup>13,14</sup>

To overcome the side effects of HP during in-office bleaching, supplementary therapies after bleaching (such as the application of fluoride) have been recommended. Fluoride may act as a remineralizing agent by forming a calcium

fluoride layer on enamel, which inhibits demineralization and decreases microhardness values.<sup>10,15,16</sup>

A nanohydroxyapatite-based remineralizing agent (Nano-P, FGM Produtos Odontologicos) was recently introduced in Brazil. This product has the ability to provide calcium, phosphate, and fluoride ions to a demineralized tooth surface. These ions can be reorganized in the form of hydroxyapatite, fluorapatite, or calcium fluoride, offering acid resistance similar to that found in natural teeth. However, there has been little study as to whether its application after bleaching will promote enamel mineral recovery. This study analyzed how both the pH of a bleaching gel and the use of a fluoride- or nanohydroxyapatite-based remineralizing product affects the enamel microhardness at different time intervals after bleaching.

## Materials and methods

Sixty bovine teeth were extracted and stored in a 0.1% thymol solution. The teeth underwent soft-tissue debridement and the crowns were sectioned with double-faced diamond discs to produce the dental slabs (3 mm x 3 mm x 3 mm).

After 2 minutes of ultrasonic cleaning with distilled water to remove excess debris, the slabs were positioned in a

**Table 1. Bleaching agents, remineralizing gels, and artificial saliva specifications utilized in the present study.**

Materials	Manufacturer	Basic composition	pH
Whiteform Perox Red Gel	Formula & Acao	35% HP, thickening agent	3.5
Whitegold Office	DENTSPLY International	35% HP, Carbopol, glycerin, calcium hydroxide	7.0
2% NaF gel	Formula Ativa	2% NaF, glycerin, deionized water, thickening agent	8.0
Nano-P	FGM Produtos Odontologicos	Nanohydroxyapatite, NaF, potassium nitrate, thickening agent, distilled water	8.2
Artificial saliva	Formula Ativa	Calcium chloride (0.166 g), sodium benzoate (1.0 g), carboxymethylcellulose (10 g), magnesium chloride (0.05 g), potassium chloride (0.62 g), sodium chloride (0.025 g), sorbitol (42.74 g), distilled water (944.53 mL), dibasic potassium phosphate (0.8035 g), monobasic potassium phosphate (0.326 g)	6.9

plastic ring and fixed with a self-curing acrylic resin. The enamel surfaces of the teeth were ground into a flat surface using silicon carbide No. 80 abrasive paper. The teeth were polished by using 400, 600, and 1200 aluminum oxide abrasive papers followed by a 0.4 µm alumina polishing suspension in a polishing machine. The slabs were cleaned again for 5 minutes in an ultrasonic cleaner. Immediately after polishing, the slabs were stored in plastic boxes with distilled water (at 37°C) for 24 hours.

Before the bleaching procedures, the baseline Vickers Hardness measurements were taken (Shimadzu HMV/2000, Shimadzu Corporation). Three indentations were made in each specimen, using a 50 kgf load for 30 seconds and a 100 µm distance between each indentation. A mean value of microhardness was calculated for each slab.

The specimens were assigned to 2 groups. Group 1 (n = 30) was bleached with a 35% HP gel, dispensed in a single bottle, with an acid pH (Whiteform Perox Red Gel, Formula & Acao). Group 2 (n = 30) was treated with a 35% HP gel, a mixture of components from two bottles, with a neutral pH (Whitegold Office, DENTSPLY International).

For Group 1 samples, a layer (approximately 1 mm) of Whiteform Perox Red Gel was applied for 30 minutes to the enamel surfaces. Per manufacturer's instructions, the teeth were rinsed and dried every 10 minutes, and the bleaching agent was re-applied. At the end of the 30-minute application, postbleaching treatments were performed.

For Group 2 samples, a layer (approximately 1.0 mm) of Whitegold Office was applied to the enamel surfaces for 30 minutes, without the need for replacement, due to the product's ability to maintain its neutral pH for a longer period of time after mixing. After 30 minutes, the whitening gel was removed, the teeth were rinsed and dried, and postbleaching treatments were performed.

Samples in both groups were divided into 3 subgroups (n = 10) according to their postbleaching treatment: storage in artificial saliva (Formula Ativa), application of a 2% sodium fluoride (NaF) gel (Formula Ativa) for 4 minutes, and a 5-minute application of Nano-P, per manufacturer's instructions. After specimens were treated with remineralizing agents, they were immersed in artificial saliva until the next whitening session. The bleaching procedures were repeated twice, 1 week apart.

After bleaching was complete, all specimens were stored in artificial saliva. Enamel microhardness was evaluated after 24 hours and after 15 days. A pH meter was used to evaluate the pH of the bleaching agents and remineralizing gels. The basic composition of the materials and their pH is described in Table 1.

Hardness data were analyzed by means of 2-way ANOVA with repeated measurements and Bonferroni tests. SPSS Version 13.0 (IBM Corporation) was used to process the data with  $P < 0.05$  used as a cutoff level for statistical significance.

**Results**

Table 2 shows that the use of 35% hydrogen peroxide acidic gel (Whiteform Perox

Red Gel) did not affect the enamel microhardness. There were no statistically significant differences among remineralizing agents ( $P > 0.05$ ) and periods of evaluation ( $P > 0.05$ ). Before bleaching, samples of all the groups were statistically similar. After the bleaching treatment, at 24 hours, and at 15 days after exposure to remineralizing products, all 3 materials provided statistically similar hardness means.

The results show that enamel microhardness was affected when the 35% hydrogen peroxide neutral gel (Whitegold Office) was applied (Table 1). Before bleaching, samples of all the groups were statistically similar. Twenty-four hours after bleaching, the enamel microhardness was not affected, and there were no statistically significant differences among remineralizing agents ( $P > 0.05$ ). However, 15 days after bleaching, the enamel microhardness significantly decreased ( $P < 0.05$ ) in the groups that used saliva and fluoride as a remineralizing agent. In the group that used the nanohydroxyapatite-based remineralizing agent, there was a statistically significant decrease between the 24h results and the results after 15 days.

**Discussion**

Hardness can be defined as resistance against deformation of the surface of a material, or against tissues subjected to penetration. As hard tooth tissues are subjected to constant pressure during function, hardness is used to detect changes in tooth tissue after experiments involving demineralization and remineralization.<sup>17</sup>

**Table 2: Mean and SD of the enamel microhardness according to the period of evaluation and remineralizing products.**

PB	RP	Periods of evaluation			P value
		Before bleaching	24 h	15 day	
Acid gel	Saliva	278.17 ± 27.32	267.07 ± 35.67	275.90 ± 57.13	$P^a = 0.609$
	F	281.67 ± 21.57	258.17 ± 25.48	303.43 ± 86.53	$P^a = 0.148$
	Nano-P	282.70 ± 23.63	304.33 ± 89.25	290.40 ± 39.39	$P^a = 0.587$
	P value	$P^b = 0.909$	$P^b = 0.181$	$P^b = 0.635$	
Neutral gel	Saliva	304.53 ± 24.48 <sup>(A)</sup>	311.60 ± 37.32 <sup>(A)</sup>	165.23 ± 45.79 <sup>(B)</sup>	$P^a = 0.001^*$
	F	329.37 ± 28.72 <sup>(A)</sup>	279.17 ± 28.25 <sup>(AB)</sup>	191.30 ± 72.77 <sup>(B)</sup>	$P^a = 0.005^*$
	Nano-P	329.23 ± 27.63 <sup>(AB)</sup>	351.97 ± 94.63 <sup>(A)</sup>	211.00 ± 43.17 <sup>(B)</sup>	$P^a = 0.032^*$
	P value	$P^b = 0.735$	$P^b = 0.347$	$P^b = 0.513$	

PB: Peroxide bleaching; RP: Remineralizing product; 24 h: 24 hours after exposure to remineralizing products; 15 day: 15 days after exposure to remineralizing products; F: 0.05% NaF.

\*statistically significant differences ( $P < 0.05$ ).

<sup>a</sup>by means of F (ANOVA) with repeated measurements.

<sup>b</sup>by means of F (ANOVA).

Means followed by different uppercase letters indicate statistically significant differences ( $P < 0.05$ ) between the periods of evaluation by Bonferroni's post-hoc test.

In-office bleaching of vital teeth often uses a high percentage of HP (25–38%). It has been reported that bleaching teeth with 35% HP does not affect the surface hardness of enamel.<sup>11,12</sup> However, it is known that the oxide reduction after use of the bleaching agent could lead to the dissolution of the organic and inorganic dental matrix until only carbon dioxide and water remain.<sup>8</sup> Studies have reported decreased microhardness in bleached enamel; in addition, it has been shown that bleaching with 35%–38% HP may alter enamel morphology and alter mineral content.<sup>6,8,9,18–21</sup> Products containing 35%–38% HP are made with different formulations, pH values, and additives (such as thickener, fluoride, desensitizing agents). These differences may explain the diversity of results found in literature.

This study used the same active bleaching agent with different pH values to evaluate the possible effects different pH values may have on enamel microhardness. The results showed that the acidic Whiteform Perox Red Gel did not affect enamel microhardness, whereas the neutral Whitegold Office gel decreased tooth hardness significantly 15 days after bleaching; though all of the postbleaching treatments

after the use of Whitegold Office were able to re-establish baseline microhardness. These results contradict those reported in 2010 by Borges et al.<sup>22</sup> Those authors found a significant reduction of hardness when an acidic gel was used in bleaching. Furthermore, the remineralizing gels used in their study significantly enhanced the microhardness of bleached enamel. However, other studies are in agreement with our research.<sup>6,23–25</sup> These studies observed that postbleaching treatments with fluoride, potassium nitrate, and amorphous calcium phosphate did not enhance the microhardness of bleached enamel.<sup>6,23–25</sup>

It was expected that HP's strong oxidizing effect on the organic matrix of teeth after bleaching would increase after using a bleaching agent with a low pH, altering the mineral composition and decreasing tooth microhardness.<sup>14,26</sup> However, the results of the present study demonstrated that the bleaching gel with an acidic pH did not affect microhardness values while the neutral bleaching gel negatively changed the enamel microhardness.

Simoes observed that the application of bleaching agents with different pH levels resulted in similar enamel microhardness values after bleaching.<sup>27</sup> Both gels, neutral

and acidic, decreased enamel microhardness. Simoes' study confirmed the 1992 study by McGuckin et al, which noted that bleaching agents, regardless of their pH value, altered the enamel surface.<sup>28</sup>

The adverse effects of bleaching on enamel microhardness found in the present study probably have more to do with the bleaching gels' formulations than with their pH. Some studies have observed that a thickening agent may decrease enamel microhardness.<sup>29–32</sup> A thickening agent is added to bleaching agents to change the liquid peroxide formulation into a gel, to avoid drainage, enhance the contact between the peroxide and the tooth, and triple or quadruple the active release time of peroxide. However, the thickening agent is an acidic polymer that may cause demineralization; in addition, it has a high calcium-binding capacity that can inhibit hydroxyapatite crystal growth.<sup>33</sup>

The presence of Carbopol (Lubrizol Advanced Materials) in Whitegold Office may have resulted in the decrease in enamel microhardness. Carbopol is an exceptional thickener, suspending agent and stabilizer, utilized in a wide variety of personal care products at concentrations lower than 1%. It is a frequent thickener in bleaching formulations, and similar detrimental effects on enamel were recorded in various studies.<sup>34–36</sup> Carbopol could act as either a demineralizing agent or as an impermeable barrier, inhibiting saliva or remineralizing products from penetrating the enamel surface and preventing the restoration of normal microhardness values.

The findings of this in vitro study may not represent in vivo conditions. In clinical situations, tooth surfaces are protected by an acquired enamel pellicle due to the washout and acid-buffering effects of saliva; as a result, enamel that is decalcified after bleaching would undergo recalcification in the presence of saliva. It could be assumed that bleaching would have no adverse effects on the tooth structure of healthy patients with normal salivary secretion.<sup>37</sup> However, the present study's results indicate that for patients with reduced salivary secretion (due to aging, systemic diseases, or medication use), it is important to consider not only a bleaching agent's pH but also its composition. Additional studies are needed to confirm if and how these materials affect enamel microhardness.

## Conclusion

Bleaching with an acidic agent did not lead to a significant reduction in enamel microhardness. However, a neutral bleaching gel caused a significant reduction of enamel microhardness. Mineralizing gels did not enhance the microhardness of bleached enamel.

## Author information

Ms. Araujo and Ms. Soares earned their doctorates in the Department of Restorative Dentistry, School of Dentistry, University of Pernambuco, Camaragibe, Brazil, where Ms. Nery earned her master's degree, Mr. Sales is a student, and Dr. Gerbi is a professor at the Laser Center, School of Dentistry.

## Disclaimer

The authors have no financial, economic, commercial, and/or professional interests related to topics presented in this article.

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## Manufacturers

DENTSPLY International, York, PA  
800.877.0020, [www.DENTSPLY.com](http://www.DENTSPLY.com)

FGM Produtos Odontologicos, Joinville, SC, Brazil  
55.47.3441.6100, [www.fg.ind.br](http://www.fg.ind.br)

Formula & Acao, Sao Paulo, Brazil  
55.11.5579.5885, [www.formulaeacao.com.br](http://www.formulaeacao.com.br)

Formula Ativa, Sao Paulo, Brazil  
11.3848.3333, [www.formula-ativa.com.br](http://www.formula-ativa.com.br)

IBM Corporation, Armonk, NY  
800.426.4268, [www.ibm.com](http://www.ibm.com)

Lubrizol Advanced Materials, Cleveland, OH  
216.447.5000, [www.lubrizol.com](http://www.lubrizol.com)

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# Analysis of total microbiota in dentin after mechanical or papain-based chemomechanical caries removal

Sandro Marco Stefanini de Almeida, DDS, MS ▪ Fabiana Mantovani Gomes Franca, ScD, MS ▪ Flavia Martao Florio, DDS, MS, ScD  
Glauca Maria Bovi Ambrosano, AGR ENG, MS, ScD ▪ Roberta Tarkany Basting, DDS, MS, ScD, PhD

Chemomechanical caries removal, when compared with removal using conventional rotary instruments, seems to preserve healthy tooth structure with less trauma to the patient. This study performed in vivo analysis of the total number of microorganisms in dentin after the use of conventional or chemomechanical (papain gel) caries removal methods. Analyses were performed before caries removal (baseline), immediately after caries removal, and 45 days after caries removal and temporary cavity sealing.

Sixty patients were selected for this study, each with two mandibular molars (one on each side) with occlusal caries of moderate depth, for a total of 120 teeth. For each patient, the carious lesion of one tooth was removed by conventional methods using low speed drills (Group 1). For

the other tooth, a chemomechanical method was used (Group 2). Dentin samples were collected at the 3 intervals and subjected to microbiological culture in blood agar. For the total number of microorganisms in both groups, ANOVA and Tukey tests (which considered the baseline values as a covariable) showed a higher microbial count immediately after the preparation of the cavity compared to the count at 45 days ( $P < 0.05$ ). For both groups, the total count of microorganisms in dentin decreased 45 days after placing the temporary cavity sealing.

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Traditionally, carious tissue removal is performed mechanically using curettes and steel burs in a slow speed handpiece. However, in restorative dentistry, concerns have been raised about these procedures. New methods have been developed to reduce both patient discomfort and potential deleterious effects on pulp tissue in the hope of preserving the largest possible amount of healthy dental tissue and improving patient comfort.<sup>1</sup> Compared to conventional removal methods, chemomechanical removal appears to preserve healthy tooth structure with less psychological trauma for the patient.<sup>2</sup> This conservative and non-traumatic procedure makes it possible to remove infected dentin with a dentin excavator without the need to remove healthy dentin tissue.<sup>3-5</sup>

Infected dentin is more superficial, softer, and has no remineralization capacity. The deeper dentin (denominated affected or demineralized dentin) maintains structural organization and therefore is capable of remineralization.<sup>2,6,7</sup>

The first product developed for chemomechanical caries removal was GK-101, which utilized N-monochloroglycine (NMG) and sodium hypochlorite to disorganize the collagen fibers.<sup>8</sup> Due to its slow action, this solution was replaced by the faster-acting GK-101E. In 1984, the first commercially available system

for chemomechanical caries removal was produced, which replaced NMG with N-monochloro-DL-2-aminobutyric acid (NMAB).<sup>9,10</sup> This product ruptured the infected dentin collagen, which facilitated its removal; however, the large volume required for removal, the high cost of the materials, its unpleasant taste, special equipment required for use, and the length of time it required to remove caries limited its clinical benefit.<sup>2</sup>

Carisolv (Medi-Team) followed; this transparent liquid contained 0.5% sodium hypochlorite and a red gel with a 0.1 M mixture of 3 amino acids: lysine, leucine, and glutamic acid.<sup>11</sup> Carisolv removes infected dentin more effectively than demineralized dentin and decomposes cellular components while preserving extracellular matrix components.<sup>12</sup> It is biocompatible for application on dentin, as it does not decompose collagen fibers; however, it is expensive.<sup>13</sup> In 2005, Bussadori et al introduced Papacarie (Formula & Acao), a papain- and chloramine-based gel that acts on demineralized dentin, allowing for removal with manual instruments while also disinfecting the cavity.<sup>3</sup> Papain is an endoprotein with bacteriostatic, bactericide, and anti-inflammatory properties. Due to the absence of alpha-1-antitrypsin, a plasmatic antiprotease which impedes proteolytic action on tissues that are considered

healthy, papain acts only on lesioned tissue.<sup>14</sup> Conversely, Bertassoni & Marshall observed partial degradation of non-demineralized Type 1 collagen fibrils.<sup>15</sup>

Chloramine is a compound formed during a reaction between chlorine and ammonia. It has bactericide and disinfectant properties and is widely used as a root canal irrigation solution that chemically softens carious dentin.<sup>14,16</sup> This gel offers biocompatibility, selectivity, and efficacy in caries removal, with maximum preservation of healthy dental tissues.<sup>3,17</sup>

However, the bactericidal effectiveness of the Papacarie system has not been evaluated with the use of clinical methodology for the removal of the total amount of microorganisms from the cavity. There is a strong correlation between the presence of microorganisms, the development of dental caries, and the progression of the carious process.<sup>18</sup> This study sought to evaluate conventional and chemomechanical methods of carious tissue removal on total microbiota of dentin at 3 collection times.

## Materials and methods

This study utilized a total of 120 carious mandibular molars, taken from 60 patients (2 molars from each patient). The patients received restorations following treatment to remove carious tissue. Tissue was removed via conventional rotary



Fig. 1. Infected dentin removal with an excavator, showing a softened and disorganized dentin.

method (a slow speed bur) and a chemo-mechanical method (Papacarie). Dentin samples were taken before carious tissue removal (at baseline), immediately after carious tissue removal, and 45 days after carious tissue removal and temporary cavity sealing.

**Sample selection, cavity preparation, and microbiological analysis**

Sixty patients (ages 18 to 47) with permanent dentition were selected from among those who sought dental assistance at the Dental Clinic of the University of Cuiaba, Brazil. As an inclusion criterion, each patient was required to have at least 2 bilateral mandibular molar teeth (first, second, or third molars) with occlusal caries lesions (visualized radiographically) at a depth of no more than 2 mm next to the pulp (medium depth) and without irreversible pulpitis. The caries lesions could only show activity (in the stage of progression) at the occlusal surface. Patients who demonstrated any type of allergy to the materials used in this study were excluded.

The patients were informed of the content of the research, and gave their written consent to participate in the study. For each patient, a random selection was made in which tooth would be treated by conventional caries tissue removal (Group 1), and which tooth would be treated chemo-mechanically (Group 2).

After anesthesia and prophylaxis, rubber dam isolation was performed. When necessary to obtain access to dentin, a spherical diamond bur tip 1012 was used at high

**Table 1. Composition and lot number for each of the chemical agents used to remove carious tissue and provide temporary cavity sealing.**

Materials	Composition	Lot No.
Papacarie	Papain, chloramine, toluidine blue, salts, preservatives, thickening agents, vehicle	0012
IRM	Powder: zinc oxide and PMMA (reinforced polymer) Liquid: eugenol, glacial acetic acid	211851B

**Table 2. Sample groups obtained in the course of study.**

Group	Treatment
Conventional baseline	Microbiologic analysis of infected dentin before using the conventional method of caries removal
Chemomechanical baseline	Microbiologic analysis of infected dentin before using the chemomechanical method of caries removal
Immediate conventional removal	Microbiologic analysis of dentin performed immediately after using the conventional method of removal
Immediate chemomechanical removal	Microbiologic analysis of dentin performed immediately after using the chemomechanical method of removal
Conventional removal after 45 days	Microbiologic analysis of dentin 45 days after using the conventional method of caries removal and the temporary cavity sealing was placed
Chemomechanical removal after 45 days	Microbiologic analysis of dentin 45 days after using the chemomechanical method of caries removal and the temporary cavity sealing was placed

speed and under water spray cooling. Food particles present in the most superficial portion of the lesion were removed with a previously sterilized dentin excavator, taking care to remove only the food debris.

For the initial evaluations in both groups (baseline counts), a No. 1 carbide bur at slow speed was used. The active tip was inserted deep into the cavity once to obtain the baseline counts; the scraping obtained was sent for a microbiological examination before the removal of any carious tissue. The infected dentin that was removed appeared softened and disorganized, varying in color from light yellow to brown (Fig. 1). The quantity of dentin removed was only that which remained on the active tip of the bur. The dentin samples were placed in test tubes containing BHI medium and incubated immediately under microaerophilic conditions (at 37°C) for 48 hours.

For Group 1 samples, all of the infected carious dentin was removed with a No. 2 or No. 3 carbide bur, taking care to preserve the affected dentin. The affected dentin was not as soft as the infected dentin; however, its color also ranged from light yellow to brown. The affected demineralized dentin sample was collected with a sterile No. 1 carbide bur at slow speed. The active tip was inserted deep into the pulp wall once (using little pressure) to collect the sample from the pulp wall, which was sent subsequently for a microbiologic examination. The tooth was temporarily restored with modified zinc oxide eugenol cement (IRM, DENTSPLY Caulk).

Forty-five days after restorations were placed, the cement was removed completely from the cavity with a No. 3 carbide bur (taking care to avoid touching the cavity walls) until the cavity was clean and without any temporary material residue.

**Table 3. Mean (standard deviation) of microbiologic count (in CFU) for total microorganisms based on removal methods and collection time.**

Time	Collection times	
	Conventional removal	Chemomechanical removal
Baseline (covariable)	2.99 x 10 <sup>4</sup> (±1.48 x 10 <sup>3</sup> )	1.19 x 10 <sup>5</sup> (±1.07 x 10 <sup>3</sup> )
Immediate	3.62 x 10 <sup>4</sup> <sup>Ba</sup> (±2.31 x 10 <sup>3</sup> )	1.34 x 10 <sup>5</sup> <sup>Aa</sup> (±2.90 x 10 <sup>3</sup> )
45 days after	3.17 x 10 <sup>4</sup> <sup>Bb</sup> (±2.58 x 10 <sup>3</sup> )	1.20 x 10 <sup>5</sup> <sup>Ab</sup> (±2.33 x 10 <sup>3</sup> )

Means followed by different letters (capitals in the horizontal and lower case in the vertical) differ by ANOVA and the Tukey test ( $P < 0.05$ ).

The remaining dentin was rigid and shiny with a light yellow color.

For Group 2 samples, the cavity was dried after the initial evaluation and Papacarie was applied, filling the cavity to the occlusal face. The Papacarie was left for 3 minutes; at that point, the chemical agent and the softened dentin residues were removed, using the cutting portion of a dentin excavator whose size was compatible with that of the cavity. This process was repeated twice for a total of 3 applications. Dentin was collected with a No. 1 carbide bur (as with Group 1 samples) and the tooth was restored temporarily with IRM.

As with Group 1 samples, the IRM was removed completely from the cavity after 45 days and a dentin sample was collected. The cavities were lined with a glass ionomer cement (Vidrion F, SS White) and restored with a microhybrid resin composite (Filtek Z250, 3M ESPE). The chemical agents used to remove the carious tissue and to provide the temporary cavity sealings are described in Table 1.

At no time did more than 30 minutes elapse between the time samples were collected and when they were processed.<sup>19</sup>

Six sample groups were created, according to the caries removal method (conventional or chemomechanical) ( $n = 60$ ) and time of collection: conventional baseline, chemomechanical baseline, immediate conventional removal, immediate chemomechanical removal, conventional removal after 45 days, and chemomechanical removal after 45 days (Table 2).

After 48 hours of incubation in BHI medium under CO<sub>2</sub> conditions (at 37°C), the samples were homogenized. Using a 10 µL calibrated nickel-chrome

bacteriologic loop, each sample was seeded in blood agar culture media for the growth of total microorganisms.

To observe colony growth, the samples were incubated for 48 hours in blood agar culture media in a bacteriologic oven under microaerophilic conditions (at 37°C). All macroscopically different types of colonies were selected; bacterial smears were taken from these colonies and Gram-stained. The characteristics of the existent microorganisms were observed in terms of staining (Gram-positive or Gram-negative), morphology, and disposition within each colony. Colony forming unit (CFU) counts were performed on the plates that contained them.

The data obtained in CFU/mL underwent an exploratory analysis, which indicated the need for parametric analysis. The statistical analysis of variance (ANOVA) for repeated measures and the Tukey test (which considered the baseline groups as a covariable) were applied, with a 5% level of significance for both.

## Results

The ANOVA showed a statistical difference between the collection times ( $P < 0.0001$ ) and between the caries removal methods ( $P < 0.0001$ ) for the total microorganism counts. The interaction between collection times and the removal methods was not significant ( $P = 0.1948$ ) in terms of the total microorganism counts. The results obtained showed statistically significant differences between Groups 1 and 2 in the immediate and 45-day total microorganisms counts. Among Group 1 samples, there were significant differences in terms of the total microorganism count between collection

times, with a higher microbiologic count in the immediate collection time ( $P < 0.05$ ). Group 2 samples also demonstrated a significantly higher microbiologic count at the immediate collection time compared to the 45-day collection time ( $P < 0.05$ ) (Table 3).

## Discussion

The traditional concept of dentin caries lesion removal is based on removing all carious dentin, including the infected and affected regions.<sup>1,20</sup> However, carious lesions advance in an irregular manner, initially affecting the more superficial intertubular (less mineralized) dentin rather than the deeper intertubular dentin. After bacterial proteolytic enzymes lead to dentin demineralization, the collagen begins to disintegrate progressively.<sup>6,21</sup>

In superficially infected dentin, one can find agglomerations of collagen fibers disposed in a dispersed manner, reduced quantities of collagen precursor molecules and hydroxyapatite crystals, and the presence of bacteria. Once the passages have been widened by the loss of peritubular dentin, and have no odontoblastic processes within them, the bacteria seal the hollow passages of the dentinal tubules with an amorphous material.<sup>2</sup> Due to the rupture of many dentin tubules, fissures and completely disorganized collagen are observed in the dentin tissue. These zones may continue to increase and unite so that infected dentin can be removed fairly easily. The denaturing of collagen reduces its capacity to serve as crystallization nuclei, making it incapable of remineralization.<sup>21</sup> However, remineralization of the deeper layer (affected or demineralized dentin) has been observed.<sup>5</sup> This affected dentin is partially demineralized, with intact collagen fibers, peritubular dentin, odontoblastic processes, and tubules that are not infected by microorganisms.<sup>22</sup>

Making a differential clinical diagnosis between infected and affected dentin depends on each dentist's skill and experience, as differentiation between these layers is based on such subjective criteria as consistency, color, and sensitivity. Methods less invasive than conventional removal are being developed and chemomechanical caries removal should be considered, as it is conservative and generally requires no anesthesia.<sup>1-4</sup>



Fig. 2. Affected dentin that remained in a Group 2 cavity. It was light yellow and not as softened as the infected dentin.

To make the chemomechanical technique more accessible, a biomaterial containing papain, chloramine, and toluidin blue (Papacarie) was created.<sup>3</sup> At a low cost, this substance allies the properties of selectivity and efficacy in removing caries with maximum preservation of the healthy dental tissues. According to Correa et al, Papacarie use led to an amorphous layer similar to the smear layer and few areas with exposed dentinal tubules.<sup>23</sup> By comparison, the conventional removal method resulted in a uniform and smooth surface with a smear layer.<sup>23</sup>

Chemomechanical caries removal methods have an antimicrobial effect; by acting directly on the bacteria, they promote bacterial destruction and consequently remove the etiologic agent. Flindt wrote that papain is an endoprotein with bacteriostatic, bactericidal, and anti-inflammatory properties and acts only on lesioned tissue.<sup>14</sup> An in vitro study by Ferreira et al demonstrated that this agent had a lower bactericidal effect compared with other materials, which contraindicates its use in endodontics for root canal irrigation.<sup>24</sup> Based on the results obtained in the present study, the papain-based chemomechanical agent with mechanical removal reduced the microorganism count and could offer antimicrobial properties against total microorganisms. It should be noted that the caries removal process was fundamental for eliminating necrotic and infected dentinal tissue from the infected dentin and reducing the microorganism counts. The consistency of Papacarie in gel form limits

its in-depth penetration; as a result, not all of the microorganisms present in the demineralized dentin are eliminated during the caries removal process. The dentin in the cavity still had a clinical aspect similar to that of infected carious tissue after Papacarie use (Fig. 2). Although the dentin was more consistent, it remained rough and darkened, indicating that the caries lesion was removed only partially.

There was a significant reduction in total microorganism counts immediately after using Papacarie and at the 45-day collection time. This reduction could be attributed to the antimicrobial effect of eugenol, and to the sealing effect of the modified ZOE-based temporary restorative material, which results in the absence of the substrate required by microorganisms and leads to their inactivation.<sup>25,26</sup> It should be noted that there are always microorganisms in the cavity after total excavation of a carious lesion, making it important to reduce or prevent microorganism proliferation by cavity sealing.<sup>27</sup> When this occurs, another permanent restorative material should be used alone or in association with glass ionomer, as it is a cariostatic and anticariogenic material that could prevent or eliminate this growth.<sup>27-29</sup>

It has been observed that the use of Papacarie results in smaller-sized cavity preparations, while lowering the amount of carious tissue and sound dentin removed.<sup>3,4</sup> As a result, more healthy tooth structure capable of remineralization is preserved. The degree of hardness can be verified due to the differences in mineralization between infected dentin (softened) and affected dentin (hard). According to Hodrova, removing more of the remaining dentin does not ensure total removal of microorganisms.<sup>30</sup> Bittencourt et al indicated that the quantity of dentinal tissue removed with Papacarie affects only the infected dentin, bearing in mind that it becomes softer, following the principles of more conservative preparation and the contemporary philosophy of preventive dentistry, which indicates that more healthy bone structure should be preserved.<sup>21</sup>

Although chemomechanical removal is a slow method, it has a high degree of acceptance among odontophobic and nervous patients. It is also highly regarded among pediatric dentists because it offers a more conservative removal option in

sites close to the pulp than more invasive rotary instruments.<sup>31</sup> Carious tissue must be removed effectively to prevent residual microorganisms in the cavity from leading to secondary carious lesions. From this aspect, there was a reduction in microorganisms after the two caries removal methods were performed.

## Summary

In the present study, conventional methods for removing carious tissue led to a reduction in the total number of microorganisms in dentin. Reductions also were noted with the chemomechanical agent, both immediately after removing the carious tissue and 45 days after placement of the temporary cavity sealing.

## Author information

Dr. de Almeida is a postdoctoral candidate, Department of Restorative Dentistry, Dental School and Institute and Research Center Sao Leopoldo Mandic, Campinas, Sao Paulo, Brazil, where Drs. Franca and Basting are professors and Dr. Florio is a professor, Department of Preventive and Social Dentistry. Dr. Ambrosano is a professor, Department of Preventive and Social Dentistry, Dentistry School of Piracicaba-Unicamp, Sao Paulo, Brazil.

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## Manufacturers

DENTSPLY Caulk, Milford, DE  
800.532.2855, [www.caulk.com](http://www.caulk.com)  
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011.5579.5885, [www.formulaeacao.com.br](http://www.formulaeacao.com.br)  
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46.0.31.7806820, [www.mediteam.com](http://www.mediteam.com)  
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**Exercise No. 333 Operative (Restorative) Dentistry Subject Code 250**

The 15 questions for this exercise are based on the article, *Analysis of total microbiota in dentin after mechanical or papain-based chemomechanical caries removal*, on pages 59-63. 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 difference between conventional and chemomechanical caries removal methods;
- understand the components of chemomechanical caries removal materials; and
- review the physiological process of the carious dentinal lesion.

1. Chemomechanical caries removal has been shown to do all of the following except one. Which is the exception?
  - A. Reduce patient discomfort
  - B. Shorten treatment time
  - C. Decrease deleterious effects on the pulp
  - D. Preserve tooth structure
2. Teeth that were used in the study were \_\_\_\_\_.
  - A. maxillary bicuspids
  - B. maxillary molars
  - C. mandibular bicuspids
  - D. mandibular molars
3. Compared to chemomechanical removal methods, conventional removal methods appear to remove healthy tooth structure. These conventional methods can cause more psychological trauma to the patient.
  - 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.
4. Analysis of the total number of microorganisms present was performed at caries removal, then at \_\_\_\_ days after caries removal.
  - A. 15
  - B. 30
  - C. 45
  - D. 60
5. Carisolv is composed of all of the following amino acids except one. Which is the exception?
  - A. Tryptophan
  - B. Lysine
  - C. Leucine
  - D. Glutamic acid
6. Carisolv removes infected dentin more effectively than demineralized dentin; however, it will decompose collagen fibers.
  - 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.
7. The first commercially available chemomechanical caries removal system was \_\_\_\_\_.
  - A. NMAB
  - B. GK101E
  - C. Carisolv
  - D. Papacarie
8. What was used to collect dentin during initial evaluation?
  - A. No. 1 carbide bur at slow speed
  - B. Dental excavator
  - C. No. 3 carbide bur at high speed
  - D. No. 8 carbide bur at slow speed
9. Papacarie was placed in the cavity for exactly \_\_\_\_ minute(s) during the initial chemomineralization treatment.
  - A. 1
  - B. 2
  - C. 3
  - D. 4
10. Papacarie was used for a total treatment time of \_\_\_\_ minutes.
  - A. 3
  - B. 6
  - C. 9
  - D. 12
11. At the initial treatment, Group 1 infected dentin appeared \_\_\_\_\_.
  - A. disorganized
  - B. black
  - C. shiny
  - D. rigid
12. After initial treatment, glass ionomer was used to restore both Group 1 and Group 2 teeth. At the end of the study, microhybrid composite resin was used for the final restorations.
  - 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.
13. Differential clinical diagnosis between infected and affected dentin depends on all of the following except one. Which is the exception?
  - A. Color
  - B. Consistency
  - C. Dentist's skill
  - D. Choice of instrumentation
14. The use of papain-based chemomechanical agents produced all of the following results except one. Which is the exception?
  - A. Reduced microorganism counts
  - B. Less sensitivity to the patient
  - C. Removal of necrotic dentin
  - D. Deep penetration into cavity
15. Patients were selected for the study if they had decay on the \_\_\_\_\_ surface of the tooth.
  - A. lingual
  - B. buccal
  - C. proximal
  - D. occlusal

**Answer form is on page 80. Answers for this exercise must be received by June 30, 2014.**

# Clinical identification of head and neck lymphadenopathy: a diagnostic obligation

Morton I. Lieberman, DDS ▪ Thomas H. Ward, DMD, MPH, FACP ▪ Michael A. Siegel, DDS, MS, FDS RCSEd

The purpose of this article is to reinforce the need for all dental clinicians to perform a complete lymph node examination on every patient, regardless of age, gender, or chief complaint. As early diagnosis provides for the best prognosis, head and neck lymph node palpation may be the earliest indicator of infection or neoplasia. This article provides the rationale for

lymph node examination, the palpation techniques for the clinician to utilize, and the anatomic locations and descriptions of lymph nodes.

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Any examination performed by a dental diagnostician is preceded by a thorough and complete medical history, followed by data collection appropriate to the patient's chief complaint. In addition to obtaining the patient's complete dental history, the dentist questions the patient about existing medical conditions, medications, allergies, social habits (such as smoking and alcohol use), family history, and any other pertinent factors concerning health. A questionnaire is completed to avoid missing any conditions that may influence care and well-being. Positive responses to the questionnaire should be elaborated upon by the patient to the dentist. The examining dentist must be aware of any unusual extraoral conditions such as skin lesions, slurred speech, facial anomalies and asymmetries, or any other clinical abnormalities that indicate further investigation. Findings may necessitate patient referral to a physician or dental specialist, or may be pertinent to the patient's chief dental complaint. Blood pressure, pulse rate, and rhythm are documented, and discussion and reinforcement of compliance with prescribed medications is essential. Consultation with the patient's physician may be necessary to clarify information, request laboratory tests, or review preexisting laboratory test results. All of this information is intended to safeguard the patient, aid in dictating limits of treatment or procedures that may endanger the patient's health, and provide important information to the dental clinician that may assist in diagnosis and/or modify the treatment plan.

Following the medical history and collection of subjective data (symptoms), the physical examination, intended to document objective findings (signs), begins with an evaluation of head and neck lymph nodes, utilizing an anatomy-based, reproducible method of systematic manual palpation (Fig. 1). It is incumbent upon the dental diagnostician to search for lymphatic abnormalities in every patient, regardless of age, gender, or chief complaint. Critical to this examination is an understanding of the anatomic distribution and drainage of head and neck lymph nodes, the features of lymph nodes

that may be encountered, and the possible pathologies that abnormal nodes may represent. Referral for treatment of infection, or indication for biopsy of possible malignancy, may be life-saving measures.

The purpose of this article is to encourage the dental diagnostician to plan and perform a thorough head and neck examination prior to the usual oral examination.

## Overview

The human lymphatic system is part of the general circulatory system and is concerned with the immune system and its disease-fighting elements.<sup>1</sup> It is different,

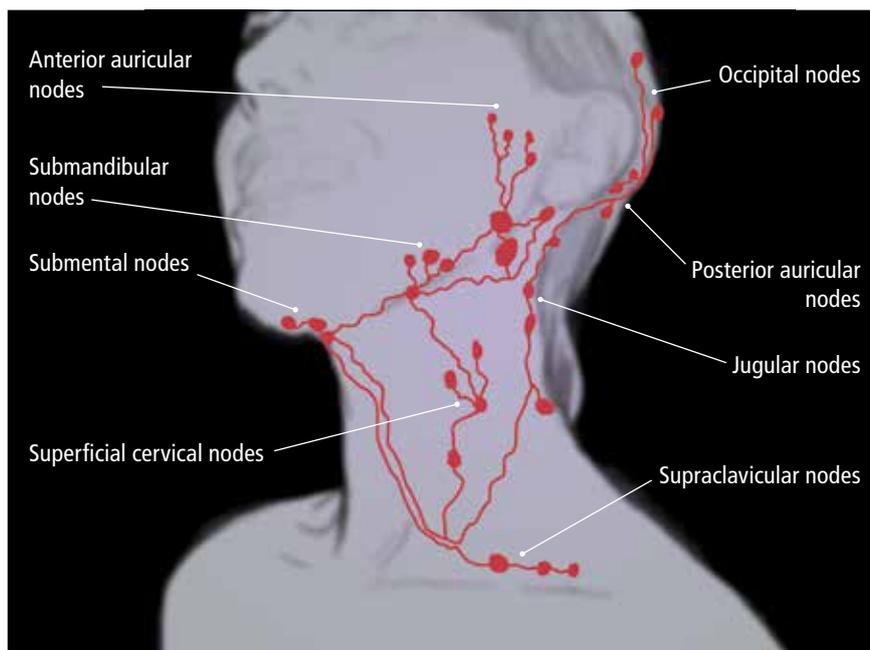


Fig. 1. Anatomic distribution of the head and neck lymph node chains.

yet similar, to the circulatory system. Involved in the transport of deep tissue fluids, the lymphatic system has no pulse, valves, or pumping mechanism as the circulatory system does, yet it flows steadily through established tubules impelled by body movements and breathing. It commingles with the circulatory system via capillaries and drains into the left subclavian vein via the thoracic duct.<sup>1</sup> All lymphatic fluid in the body drains into the supraclavicular lymph node (known as *Virchow's node*) which is located on the midline of the left clavicle.<sup>2</sup> Therefore, any metastatic tumor originating below the clavicles must drain through this node.

Lymphocytes formed by the nodes are an essential part of the body's immune system.<sup>1</sup> Lymph nodes contain both B and T cells that are responsible for humoral and cell-mediated immunity, respectively.<sup>1</sup> Through a "blood-lymph loop," they respond to inflammation—as a result of bacterial, fungal, and viral infectious diseases—by swelling; when hard, they may also serve as a signal for malignant growth.<sup>1</sup>

What follows is an outline and suggestion of a routine inspection sequence of head and neck nodes, and some of the disease processes that influence regional lymphadenopathy. The dentist is obliged to perform careful and methodical lymph node palpation. Once an abnormal node has been discovered, either referral, or further diagnostic modalities must be pursued. Referral must provide a description of the exact location and evaluation of the abnormal findings. The referring dentist should request a report of any additional findings and recommendations which should be entered into the patient record. Appropriate follow-up must be arranged. It is imperative that there be an understanding of the significance of any abnormalities so that communication with an oral diagnostician (oral medicine/oral pathology) primary care physician, and/or medical oncologist, will be accurate and informative. The patient must be made to understand the necessity for further consultation and investigation. Early diagnosis and treatment can slow or halt progression of disease, leading to a decrease in both morbidity and mortality.

It has been reported that 25% of patients with oropharyngeal cancer die from the disease and that the 5-year survival rate is estimated at 57%.<sup>3</sup> Hodgkin's lymphoma may



Fig. 2. Bilateral palpation of the suboccipital lymph nodes using the base of the skull as a firm surface against which to palpate.

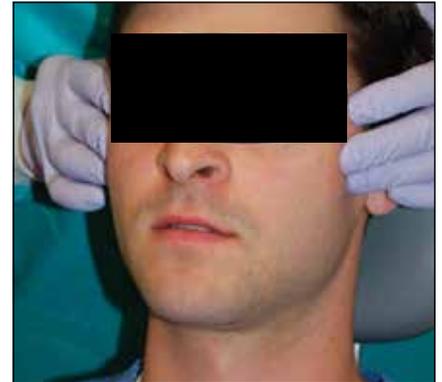


Fig. 3. Bilateral palpation of the pre- and postauricular lymph nodes utilizing the mandibular ramus and coronoid process as a firm surface against which to palpate.



Fig. 4. Bilateral palpation of the submandibular/submental lymph nodes utilizing the anterior inferior border of the mandible as a firm surface against which to palpate.



Fig. 5. Bimanual palpation of the submental lymph nodes via the floor of the mouth utilizing the right hand of the operator as a firm surface against which to palpate.

be diagnosed by the dentist from abnormal cervical and supraclavicular nodes. Early stage discovery and treatment offer the best chance for cure.<sup>4</sup> Cervical lymphatic abnormalities most often lead to findings for reactive and granulomatous diseases. Carcinomas and lymphomas follow in frequency.<sup>5</sup> A careful palpation and evaluation of cervical lymphadenopathy is as accurate as an ultrasound examination.<sup>6</sup>

### Lymph node examination techniques

The proper and most efficient way to palpate lymph nodes is to press them gently against a firm surface (such as a bone or a taut muscle), or to apply counter pressure to the sternocleidomastoid (SCM) muscle,

with fingers on the opposite sides of the nodes. It is suggested that the investigation be systematic, so that each patient is examined in the same way.<sup>7</sup>

There are 3 basic techniques for lymph node palpation.<sup>7</sup> *Bilateral* palpation is performed standing behind the patient while feeling both sides of the neck, simultaneously utilizing the SCM muscle as the firm surface. *Bimanual* palpation uses 2 hands at one site, such as when palpating the submandibular gland. *Bidigital* palpation uses 2 fingers, such as when palpating a nodule in the buccal mucosa. The pattern of examination is similar to that devised by the American Academy of Otolaryngology and the American Joint Committee on Cancer.<sup>7</sup>



Fig. 6. Bimanual palpation of the jugular and posterior cervical lymph nodes utilizing the right hand to anteriorly stabilize the SCM muscle to form a firm anterior surface against which to palpate.



Fig. 7. Bilateral palpation of the supraclavicular nodes utilizing the clavicle as a firm surface against which to palpate. Special attention should be addressed to the left supraclavicular node (Virchow's node), as this represents the emptying of the thoracic duct.



Fig. 8. Digital palpation of the thyroid gland.

## Types of lymph nodes

### **Suboccipital**

These are palpated at the base of the occipital bone (Fig. 2). They drain the scalp area and usually do not reflect more than local infection.

### **Pre- and postauricular**

These nodes are located just anterior to the ears and at the mastoid areas (Fig 3). Palpable findings of these nodes may reflect an infection such as inoculation lymphoreticulosis, also known as cat scratch fever, or granulomatous changes, such as tuberculosis or sarcoidosis.

### **Submandibular**

Palpate with fingertips and roll the nodes over the inferior border of the mandible (Fig. 4). The nodes should be soft and moveable. Soft, tender enlargement may indicate head and neck infection, and hard fixed nodes may indicate malignancy.

### **Submental**

Palpation technique is similar to the submandibular nodes but may also be accessed via the floor of the mouth (Fig. 4 and 5). Abnormal nodes may result from viral infections such as Herpes simplex (herpes labialis), Varicella-Zoster (shingles), or bacterial dental infections.

### **Jugular and posterior cervical**

These nodes are located along the SCM muscle and can be palpated with

counter-pressure using 2 hands or the thumb and fingertips of each hand (Fig. 6).

### **Supraclavicular**

Palpate with fingertips in the hollow above the clavicle (Fig. 7). Nodes on the right side drain the mediastinum, esophagus, and lungs. Abnormalities may indicate malignancies of the lung or intestines. The left side drains the thorax and abdominal cavity. Virchow's node may be palpated in the left supraclavicular area. Enlargement signals metastatic cancer of these regions which may metastasize through the thoracic duct and may be palpated close to its joining with the left subclavian vein.<sup>4</sup>

While examining the neck, it is recommended that the diagnostician palpate the thyroid gland for enlargement or nodules (Fig. 8). If any abnormality is present, referral for medical consultation and evaluation is indicated.

### **Other modalities to identify lymphadenopathy**

MRI has proven to be accurate in differentiating between malignant and benign tumors. MRI results have been correlated with biopsies and PET scans of cervical nodes associated with cat scratch fever, non-Hodgkin's lymphoma, sarcoidosis and reactive lymphadenitis.<sup>8</sup> Color Doppler sonography is also a useful diagnostic tool to identify abnormal lymph nodes by shape, necrosis, calcification, and peripheral vascularity.<sup>9</sup> Ultrasound and/or fine

needle aspirations are used to further study the nature of the disease via the cytologic examination of the cells withdrawn from the tumor through the needle. The definitive diagnostic tool is the biopsy, requiring surgical removal and microscopic examination of the involved lymph node. Human papilloma virus (HPV) has been associated with head and neck squamous cell carcinoma. Location of the primary site may be determined by the presence of HPV-16 or HPV-18, which indicates that the tumor is located in the oropharyngeal region with 71% accuracy.<sup>10</sup>

### **Significance of lymph node examinations**

There are 3 basic classes of lymph nodes. Fibrotic nodes are palpated as scarred jelly bean-like structures that are freely movable and escape from the clinician's fingers. They are usually representative of previous infection. Tender, enlarged, and inflamed nodes are usually indicative of an active infection and are referred to in lay terms as *swollen glands*. Stony hard and fixed nodes feel like marbles that cannot be moved from the underlying structures and usually represent some form of neoplasia.<sup>7</sup>

The lymph nodes are the source of cells which enhance the immune system and facilitate our ability to fight disease.<sup>7</sup> T cells, B cells, and natural killer cells (NK) are formed within the nodes. During viral and bacterial illnesses that require the assistance of these cells to fight infection

or inflammation, the nodes react with hyperactivity causing soft swelling and warmth.<sup>11</sup> Cardinal signs of inflammation include redness, swelling, pain, increase in temperature and loss of function. Absence of NK cells can lead to premature death from uncontrolled viral infections.<sup>8</sup>

The lymphatic system is also involved in malignant diseases, such as lymphomas and cancers, which may metastasize through nodes causing an overproduction of lymphocytes to the extent that the cells burst out of the node's surrounding capsule to become firm and fixed.<sup>11</sup> Epithelial tumors metastasize through lymphatics and the extent of lymphatic spread is the basis for staging malignancy. The primary involved node is referred to as the sentinel node.<sup>11</sup>

Until recently, traditional staging dealt with tumor migration, while grading was judged by microscopy. A valuation of I to IV was assessed and oncological treatment plans were carried out accordingly. In 2010, a fact sheet published by the National Cancer Institute (NCI) expressed staging in more complex and meaningful terminology.<sup>12</sup> Accurate staging is essential for prescription of effective treatment as well as for evaluation of prognosis and progress.

The NCI system is abbreviated as *TNM*, where *T* refers to the tumor, *N* evaluates spread to regional lymph nodes, and *M* reflects distant metastasis.<sup>12</sup> Each of these factors is assigned an evaluation number which literally describes the stage of the malignant lesion in terms which are universally accepted and applied to treatment planning.<sup>12</sup> Modalities of tests utilized in staging include physical examination, imaging—magnetic resonance imaging (MRI) and positron emission tomography (PET)—and surgical or fine needle biopsy, with microscopic evaluation.<sup>12</sup>

Recognition of abnormal lymph nodes is reportedly efficient in predicting and diagnosing the metastatic spread of cancer. One study stated that palpation of cervical nodes was 81.1% accurate in diagnosing the presence of malignancy.<sup>13</sup> A British study demonstrated that preclinical medical students were as accurate as ENT surgeons in assessing cancerous nodes but were not as efficient in staging.<sup>14</sup> Painful, soft enlargement generally indicates inflammation or infection, while firm fixed painless nodes are generally due to

malignant change. Cervical lymphadenopathy reflects the presence of mycobacterial infection. It is the most common extrapulmonary symptom of tuberculosis.<sup>15</sup>

### Other etiologies for lymphadenopathy

A variety of common medications may result in enlarged lymph nodes. Some of these include Allopurinol, Atenolol, Penicillin, Bactrim, and Dilantin. Disease conditions involved with nodal abnormality include, among others, mononucleosis, sarcoidosis, Gaucher's disease, Niemann-Pick disease, hyperthyroidism, Kawasaki syndrome, and severe hypertriglyceridemia.<sup>16</sup>

### Conclusion

This article presents a rationale and technique for head and neck lymph node examination, and explains the importance of the lymphatic system. Systematic manual palpation has been found to be an accurate modality for determination of pathology. If this examination is not performed and abnormalities are not recognized, potentially fatal pathologies could go undiagnosed and untreated.

The dental practitioner must perform the lymphatic examination as a repetitive and routine procedure. It must precede intraoral and radiographic examination. Conscientious adherence to this diagnostic methodology can save lives. It is a mandatory procedure in the dental diagnostician's armamentarium. Its importance cannot be overstated.

The authors do not minimize the necessity of traditional intraoral examination and radiographic diagnostic modalities commonly utilized for the diagnosis of dental disease, as an abnormal presentation of the oral cavities bony and oral mucosal structures remain the purview of the dentist. The purpose of this paper, however, was to stress lymph node palpation as a diagnostic imperative to be carried out as part of a complete extra- and intraoral head and neck examination.

### Author information

Drs. Lieberman and Ward are assistant professors, and Dr. Siegel is professor and chair, Oral Medicine and Diagnostic Sciences, College of Dental Medicine, Nova Southeastern University, Fort Lauderdale, Florida.

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# An indirect approach for closing the space between a pontic and the alveolar ridge on an existing prosthesis

Eric Danko, DMD, MBA, FAGD, ABGD ▪ Jason Roe, DDS, FACP

This article describes an alternative method for closing the area between a pontic and the alveolar ridge. An existing restoration could be maintained by resin-bonding an onlay to the intaglio surface of the pontic. This method could be utilized for other cases when it is not

feasible to remove an existing fixed dental prosthesis.

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There are many instances when a dentist must change the treatment plan in the middle of treatment due to extenuating circumstances, such as a need or desire to complete treatment by a certain deadline. A patient who has recently lost a tooth may demand a final prosthesis sooner than the dentist would deem appropriate. Studies have shown that tissue reduction is more pronounced during initial wound healing and the majority of tissue vertical dimension change takes place during the first 3 months of healing.<sup>1,2</sup>

Several factors can affect dimensional changes in vertical and horizontal tissue. The difficulty of an extraction and the patient's gingival biotype each affect the gingiva's final healed position. Patients who require extraction and replacement of a maxillary tooth associated with high gingival scalloping and thin gingiva often require a longer healing time to determine the final healed ridge/tissue position; some authors have advocated waiting 6-12 months before completing a definitive restoration.<sup>3</sup> In an area with fewer esthetic demands (for example, the mandibular premolar/molar area), this time frame is not as crucial.

When circumstances dictate starting fabrication prematurely, remodeling may occur after inserting the final prosthesis. Some patients may appreciate a notable tissue change after premature restoration placement. One should seriously consider waiting the appropriate length of time for healing and bone and tissue remodeling to take place. Inserting the final prosthesis too early can open the door to future problems. One such problem that may

develop is space under the pontic area. This space can trap food and plaque, and be troublesome to the patient.

The dentist is then faced with a new dilemma: how to fix this situation. One method is to open up the area even more to make it a sanitary pontic, which is easier for the patient to access. Another option is to replace the fixed dental prosthesis (FDP). However, if there is already good marginal integrity, prosthesis contour and color, and the teeth are vital, removing the prosthesis could result in damage to the abutment teeth. In addition, there is the added patient cost of a second FDP. Another possibility is a periodontal surgical procedure to build up the soft tissue. This is difficult to accomplish with an FDP already inserted. Placing a direct composite is another option, although this approach may create difficulties in visibility and technique. Finally, a dentist could utilize a porcelain onlay via an indirect approach.

Reston et al indicated that esthetic and functional repairs offer many advantages compared to remaking ceramic crowns and/or bridges, which can be expensive and time-consuming.<sup>4</sup> Articles regarding direct and indirect porcelain repair have been published.<sup>4-10</sup> To the authors' knowledge, most existing literature illustrates indirect porcelain repair of prostheses cameo surfaces. The present case illustrates the occasional need to repair the pontic intaglio surface. By utilizing an indirect approach, the pontic intaglio surface can be extended to the tissue, allowing the space to be closed. The patient keeps the existing prosthesis, which saves time and money, and prevents any further trauma to the abutment teeth.

## Case report

A 38-year-old man came to the Advanced Education in General Dentistry (AEGD) 2-year program at Fort Bragg, North Carolina for periodontal treatment. The patient was motivated to get his teeth "fixed" after years of neglect. The patient did not have any significant medical conditions, although he had several hopeless maxillary and mandibular teeth requiring extraction. The treatment plan required fabricating a maxillary overdenture and four mandibular FDPs to restore the entire arch. The original treatment plan included a metal-ceramic FDP on teeth No. 18-20.

Three months after extracting the hopeless teeth, it was necessary to extract tooth No. 20, and the treatment was modified to include a metal-ceramic FDP on teeth No. 18-21. Additionally, the patient had orders to deploy in one month for a one-year duration. Since this time frame did not allow for an appropriate healing period, and the dentist did not want the patient to deploy with a provisional FDP, the plan was altered to allow for fabrication of the final prosthesis before the patient's deployment. This adjustment allowed for the preparation and impression of mandibular abutment teeth No. 18 and 21, along with subsequent extraction of tooth No. 20.

Tooth No. 20 was removed on the master cast to allow for the pontic space and fabrication of the metal-ceramic FDP for teeth No. 18-21. The fixed prosthesis was fabricated at the Army Dental Laboratory using a porcelain alloy (Foundation, Jensen Dental Incorporated) and porcelain (Creation, Jensen Dental Incorporated). The patient's maxillary overdenture and mandibular FDPs were inserted to the



Fig. 1. Lingual view of the space between the pontic and the ridge.



Fig. 2. Buccal view of the space between the pontic and the ridge.



Fig. 3. A lingual view of the polyvinylsiloxane impression showing the pontic for tooth No. 20 in the middle.



Fig. 4. The impression with the mounted stone on the articulator prior to sectioning.



Fig. 5. Intaglio view of the intended margin of the underlay.

patient's satisfaction. Two weeks postinsertion, he returned to the clinic with the news that he was no longer deploying.

Eight months after extraction of tooth No. 20 and 7 months after insertion of the metal-ceramic FDP, the patient had a food trap in the tooth No. 20 area. The patient was having a difficult time keeping food from lodging under the pontic and desired a remedy (Fig. 1). A 1 mm vertical ridge defect extended from lingual to buccal under the pontic (Fig. 2). A decision was made not to replace the FDP because the occlusion and esthetics were excellent. Instead, an all-ceramic, Empress I (Ivoclar Vivadent, Inc.) onlay (hereafter called an *underlay*) was indirectly fabricated and resin-bonded to the intaglio of the pontic, filling the space.

### Fabrication of the underlay

A 2 mm mesiodistal groove was prepared in the pontic intaglio surface with a No. 2 round diamond bur; this groove would allow for the appropriate orientation of the underlay. The final impression was made



Fig. 6. Lingual view of the underlay on the articulated cast.



Fig. 7. Buccal view of the underlay on the articulated cast.

by utilizing heavy body polyvinyl siloxane (Extrude, Kerr Corporation) from the lingual surface of the tooth. The material was expressed under the pontic areas and the adjacent surfaces of teeth No. 18 and 21, and along the entire lingual surface of the FDP. A tray was not utilized (Fig. 3). The final impression was poured, using Type V dental stone (Die Keen, Heraeus Kulzer) and articulated on a simple hinge articulator (Fig. 4). After the final stone setting, the impression material was removed, and the 2 arches were separated with

burs under magnification. The separation allowed access to the intaglio surface of the pontic. Care was taken not to disturb the intaglio of the tooth No. 20 pontic or the ridge area under the pontic. After separation, the articulator could hinge open to allow complete access and visibility to the nonhygienic area under the pontic. The area was trimmed and the intended margin outlined (Fig. 5). The underlay was fabricated via waxing and pressing Empress I ceramic. After the fit on the articulated cast was ensured (Fig. 6 and 7),



Fig. 8. Lingual view of the final prosthesis.



Fig. 9. Buccal view of the final prosthesis.

the underlay was placed. The underlay was bonded, using resin cement (NX3 Nexus, Kerr Corporation) per manufacturer's instructions. During the process, a piece of vinyl glove was placed between the ridge and pontic for 60 seconds to protect the ridge from the ceramic etching gel (IPS 5% Etching Gel, Ivoclar Vivadent, Inc.). The prosthesis was polished again after insertion to ensure a smooth marginal finish (Fig. 8 and 9).

### Summary

An indirect porcelain restoration is a successful method for repairing porcelain defects. In the present case, the area between the pontic and the ridge was closed, eliminating the food trap. Patients also prefer this procedure to replacing the entire FDP because it means avoiding the anesthesia involved when removing the old FDP and inserting a new one. In addition, this procedure means reduced chairtime for the clinician, no need to adjust occlusion, and little cause for concern in terms of restoration dislodgement. Because there are no direct forces on the underlay, the possibility of dislodgement is reduced. In addition, the existing FDP is made of porcelain and metal. As a result, any flexure strong enough to dislodge the underlay would likely fracture the original porcelain

as well. When repairing porcelain, this technique should be considered instead of replacing the entire restoration or utilizing a composite in a direct technique.

### Disclaimer

This article does not represent the views of the Department of Defense or the United States Army. Also, any mention of products or manufacturers is intended for educational purposes only and is not intended to serve as promotion of any product.

### Author information

Major Danko is a graduate of the Army 2-year AEGD at Fort Bragg, North Carolina, and is the Dental Executive Fellow, Office of the Army Surgeon General, Falls Church, Virginia. Major Roe is a graduate of the Army prosthodontic program at Fort Gordon, Georgia, and is a prosthodontic mentor in the 2-year AEGD program at Fort Bragg.

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### Manufacturers

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# Bioactive glass and connective tissue graft used to treat intrabony periodontal defects

Tatiana Miranda Deliberador, DDS, PhD ▪ Daniel Rizzo Trotta, DDS ▪ Luis Gustavo Klug, DDS, MSc ▪ Joao Cesar Zielak, DDS, PhD  
Allan Fernando Giovanini, DDS, PhD

Different techniques and materials can be used to treat intrabony periodontal defects caused by periodontal diseases. This case report presents an intrabony periodontal defect with bioactive glass and connective tissue graft used as a barrier. Probing depth and clinical attachment gain were reduced at 6 and 12 months post-treatment.

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Periodontal therapy is intended to control periodontal tissue inflammation and to stimulate the regeneration of periodontium that has been damaged by periodontal disease. To promote this regeneration, the appropriate guidance of cells capable of synthesizing collagen, cementum, and bone to the damaged site is required.<sup>1</sup>

Intrabony periodontal defects can be complex and difficult to treat. Surgical techniques, including guided tissue regeneration (GTR), have been used to regenerate tissue in these areas.<sup>2</sup> GTR involves placing a physical barrier (membrane) and allowing those cells that have regenerative capacity (periodontal ligament cells) to migrate to the area of the periodontal defect while blocking the approach of undesirable cells (such as epithelial and/or gingival conjunctive tissue cells).<sup>3,4</sup> This technique has been used with predictable results for 2- and 3-wall intrabony defects, and Class II furcation defects.<sup>5-9</sup>

Both absorbable and nonabsorbable membranes have been used as barriers, with no significant differences between the 2 in terms of the healing process.<sup>10</sup> Nowadays, absorbable membranes are used more commonly, mainly because nonabsorbable membranes require a second surgical procedure for their removal.<sup>10</sup> A connective tissue graft also could be used as a barrier for furcation defects and intrabony defects.<sup>9,11</sup> Using connective tissue graft as a barrier during GTR makes it possible to restore the hard tissue while enhancing the soft tissue profile in the same procedure.<sup>11</sup>

Several types of grafts and alloplastic materials have been used to treat periodontal defects. Bioactive glass (BG) has osteoconductive potential, and has demonstrated an osteostimulatory effect as well.<sup>12-14</sup> BG has been used to treat intrabony periodontal defects, demonstrating a significant improvement in clinical parameters (such as vertical and horizontal tissue gain in mandibular

Class II furcation defects), compared to open flap debridement (OFD).<sup>2,15,16</sup>

This case report presents a patient with intrabony periodontal defects that were treated by using BG and connective tissue graft as a barrier.

## Case report

A 72-year-old woman was referred to a periodontist with the chief complaint of pain and discomfort in tooth No. 30. Clinical examination revealed deep probing depth, with bleeding upon probing, and clinical loss of attachment levels (5 mm and 7 mm) in the medial side of the tooth (Fig. 1). Radiographic examination revealed vertical bone loss at the medial surface of the tooth (Fig. 2).

The patient underwent scaling and root planing, and received oral hygiene instructions. Two months later, the depth of the periodontal pockets and the amount of bone loss remained similar to what was observed at the initial periodontal



Fig. 1. Depth probing at the initial examination.

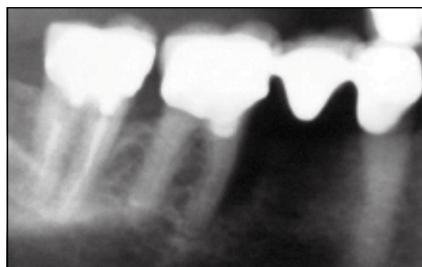


Fig. 2. A radiograph taken at the initial examination.



Fig. 3. The open flap prior to debridement.



Fig. 4. The surgical site after OFD.



Fig. 5. The area after placement of the restorative material.

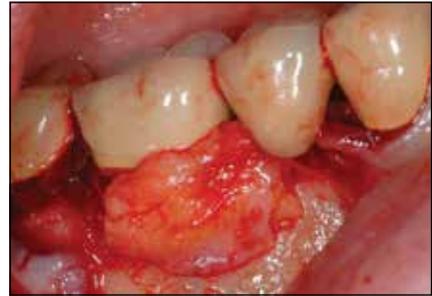


Fig. 6. An anterior view of the connective tissue placed as a barrier.



Fig. 7. The area after closure of the surgical site.



Fig. 8. Depth probing at a 1-year follow-up.



Fig. 9. A radiograph taken 1-year postsurgery.

examination. To regenerate periodontal tissue in the area, a treatment plan was proposed that would combine BG with a connective tissue graft as a barrier.

After antisepsis and anesthesia, an intrasulcular incision from teeth No. 28-31 was made, followed by a full thickness flap reflection on both the vestibular and lingual sides (Fig. 3). At that point, all granulation tissue was removed with the aid of curettes. Root surfaces were scaled, planed, and decontaminated with tetracycline hydrochloride (Fig. 4). The intrabony periodontal defect was filled with Biogran (Biomet 3i, LLC) (Fig. 5). An autogenous connective tissue graft was collected from the palate and placed gently under the flap with a suture (Vycril 5-0, Ethicon, Inc.) (Fig. 6), according to a previously described technique.<sup>17</sup> The connective tissue used as a membrane was positioned 2 mm above the mesiodistal and crown apex direction of the defect. Finally, the flap was coronally positioned and sutured with suspensory sutures (Fig. 7).

Postsurgery, the patient received pain control medication (an analgesic containing acetaminophen), antibiotic (amoxicillin

500 mg, 3 times a day for 7 days), and chemical plaque control (0.12% chlorhexidine gluconate rinse, twice a day for 14 days); in addition, the surgical sites were covered with periodontal dressing. After 10 days, the sutures and the periodontal dressing were removed and follow-up visits were scheduled for 1, 3, 6, and 12 months. At each visit, oral hygiene instructions were reinforced. The surgical site was examined to confirm that healing was uneventful.

At 6 and 12 months, a reduction in probing depth and a gain in clinical attachment could be observed. In addition, the tooth had a probing depth of 3 mm at 12 months, with a clinical attachment level of 5 mm, and no bleeding upon probing (Fig. 8). The 1-year radiographic examination showed great improvement compared to the initial exam, with almost complete closure of the intrabony defect (Fig. 9).

## Discussion

This case report involved the successful treatment of an intrabony defect by using BG combined with connective tissue graft as a barrier, which restored the bone morphology.

Previous studies reported that BG was an improvement compared to OFD when treating intrabony defects and furcation defects, demonstrating gains in clinical attachment levels, reduction of bleeding and probing depth, less gingival recession, and higher bone fill.<sup>15,18-20</sup> Conversely, a 2008 study by Pagliaro et al compared BG and surgical scaling for treating intrabony defects and reported no statistically significant differences among all clinical parameters evaluated.<sup>21</sup>

A 2010 clinical and radiological study compared 45 sites utilizing BG, biphasic calcium phosphate, and a control group.<sup>22</sup> Three and 6 months post-surgery, the authors reported not only a reduction in probing depth, but also a gain in attachment level.<sup>22</sup> Other studies have reported that BG enhances periodontal tissue healing when probing depth reduction, osseous defect fill, and clinical attachment gain are used as clinical parameters.<sup>15</sup>

In a 2005 study by Villaca et al, the authors performed a histomorphologic analysis of 2-wall intrabony defects in monkeys and demonstrated that BG had a “promising inhibition” of the apical

migration of the junctional epithelium and greater cementum deposition on the radicular surface.<sup>23</sup> Moreover, the authors reported that BG particles were used to stimulate new bone based on both their osteoconductive properties and their osteostimulatory capacity.<sup>23</sup> Previous *in vitro* studies revealed some of the critical events that occur with the use of bioactive glass—such as the enhancement of osteoblast proliferation and selectively modulated cell signaling pathways—can stimulate the expression of the osteoblast phenotype.<sup>24</sup> In addition, Granito et al found that 300-355 µm particles (like those used in the present case) offered better tissue responses compared to control, which led to bone regeneration and deposition in the damaged periodontium.<sup>25</sup>

The connective tissue graft has been used successfully as a barrier in treating root recessions and furcation defects.<sup>11,26</sup> An *in vitro* study compared absorbable and non-absorbable membranes, concluding that selecting a barrier is crucial when BG is used, as the barrier may affect cell proliferation during the process of periodontal/tissue regeneration.<sup>1</sup>

## Conclusion

This case report indicates that periodontal intrabony defects can be treated successfully with a combination of BG and a connective tissue graft.

## Author information

Drs. Deliberador, Zielak, and Giovanini are professors, Masters Program in Clinical Dentistry, Positivo University, Curitiba, Parana, Brazil, where Drs. Trotta and Klug are postgraduate students and in private practice in Curitiba.

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# Using chemical vapor deposition diamond finishing burs for conservative esthetic procedures

Adilson Yoshio Furuse, DDS, MSc, PhD ■ Leonardo Fernandes da Cunha, DDS, MSc ■ Patricio Runnacles, DDS, MSc  
Rodrigo Pirolo, DDS, MSc ■ Joao Cesar Zielak, DDS, MSc, PhD

The article demonstrates how chemical vapor deposition (CVD) diamond burs were used in a simple esthetic and cosmetic procedure to treat discolored anterior teeth. A patient who experienced discoloration after bleaching was treated with direct resin composite veneers. Excess restorative material close to the periodontium was removed with a CVD diamond bur attached to an ultrasonic handpiece. The results

indicate that CVD diamond burs are appropriate for removing excess material at the gingival margins of resin composite restorations without damaging the periodontium.

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Recurrent discoloration is a common occurrence following a walking bleach procedure.<sup>1</sup> If an alternative esthetic treatment is necessary after bleaching, direct resin composite veneers may be indicated, as large tooth reductions are not necessary with this method, and veneers are not only an inexpensive, conservative approach, but they also improve esthetics and function.<sup>2-4</sup>

Veneers are indicated for masking dental discoloration when the cervical margins of the restorations are located at or very near the subgingival area; as a result, excessive amounts of restorative material at the periodontium are common. A restoration inserted close to the gingival margin (as is the case with resin composite veneers) may have a negative effect on marginal periodontal health, due to increased plaque retention and the potential for gingival inflammation and periodontal destruction.<sup>5</sup> Additionally, an unpolished restoration is more likely to stain as a result of food and beverage intake, which could lead to discoloration and the need to replace the esthetic resin composite veneer.<sup>6</sup> Soares-Geraldo et al suggested a possible relationship between staining from exogenous sources (such as coffee, tea, or red wine) and the degradation of resin-based materials.<sup>7</sup>

Excess resin composite near the gingival margins normally is removed using diamond burs and surgical scalpels; however, this procedure can be harmful to the periodontal tissues and can result in bleeding. Diamond burs made of polycrystalline chemical vapor deposition (CVD) diamond may be used in ultrasonic handpieces to avoid injury.<sup>8</sup> These CVD diamond burs may remove similar amounts of tooth

structure compared to conventional high-speed burs; however, the removal process may be slower.<sup>9</sup> Slowly removing the restorative material and sound dental structure allows for greater precision, which would be advantageous when finishing and polishing the gingival margins of a restoration. This article presents a case in which CVD diamond burs were used to remove excess cervical restorative material after placing a direct resin composite veneer.

## Case report

A 20-year-old man reported discoloration on an endodontically treated left maxillary central incisor. Clinically, a Class IV restoration was observed (Fig. 1); according to the patient, this restoration was placed due to a fall that happened during his childhood. The patient's history and

radiography suggested intrinsic staining, possibly due to the root canal therapy.

In-office and walking bleach procedures were planned. Approximately 1 mm of root canal restoration material was removed (in the apical direction) from below the cemento-enamel junction (CEJ). A 2 mm resin-modified glass ionomer cement cervical seal (Vitremer, 3M ESPE) was placed, following the anatomy of the CEJ to prevent the bleaching agent from spreading to the periodontal ligament or the periapical area (Fig. 2). The in-office bleaching agent was applied 3 times at the same treatment session prior to utilizing the walking bleach technique (Fig. 3).

For the walking bleach procedure, a paste made of sodium perborate and water was inserted into the pulp chamber (Fig. 4). The cavity for coronal access was



Fig. 1. A preoperative view of the patient. Note the compromised esthetics due to discoloration and a Class IV restoration on the left maxillary central incisor.



Fig. 2. A radiograph taken after the application of the glass-ionomer cervical seal.



Fig. 3. An occlusal view of the dentition immediately after performing the bleaching technique.



Fig. 4. A paste of sodium perborate and water is inserted into the pulp chamber.



Fig. 5. Anterior view of the dentition after the bleaching procedure.



Fig. 6. The dentition 5 months post-treatment. Note that discoloration has recurred.



Fig. 7. An anterior view of the dentition after placement of a direct resin composite veneer and the creation of a diastema.



Fig. 8. Comparison of a conventional fine grit, diamond coated bur and a CVD diamond bur.

sealed with Vitremer. After 7 days, the in-office technique was repeated and a fresh paste of sodium perborate and water was applied to the pulp chamber. At 14 days, the in-office technique was repeated once more, and a fresh paste of calcium hydroxide and water was inserted into the pulp chamber, remaining for 2 weeks. A resin composite (Filtek Z350 XT, 3M ESPE) was used to restore coronal access. Figure 5 shows the post-bleaching results. The patient did not return for the next clinical session to replace the Class IV restoration.

After 5 months, the discoloration had recurred and a veneer was indicated. Figure 6 reveals a discrepancy in the form of the two maxillary central incisors. Using a diamond bur, a veneer preparation was made to provide sufficient space for opaque and translucent resin composites; at that point, a self-etching adhesive system (Easy One, 3M ESPE) was applied. A thin layer of Filtek Z350 XT was placed to mask the discoloration of the underlying tooth structure. A dentin shade (A2) was used to simulate the opacity of the dentin and reproduce the dentin lobes. The translucent composite was applied among the lobes to simulate the translucency of the

incisal third. To reproduce the appearance of enamel, the enamel shade was applied to the cervical (A2E) and the middle and incisal thirds (A1E). Cosmetic recontouring of the right maxillary central incisor was performed by placing resin composite to correct the morphologic asymmetry, re-establish the midline, and improve harmony, alignment, and color among the anterior teeth (Fig. 7).

The restorations were finished and polished with sequential polishing discs. Cervical margins were finished with a CVD diamond bur (CVDentus) in an ultrasonic handpiece, which produced a vibrating movement rather than a rotational movement (Fig. 8-10). To avoid damaging the sound dental structure, the tip of the diamond bur was positioned parallel to the surface of the restoration and intermittent movements were used. Intermittent movements also were necessary to avoid blocking the bur's vibration. The final restorations are shown in Figures 11 and 12.

### Discussion

Although CVD diamond burs adapted to ultrasonic handpieces were introduced to dentistry in 1996, their use has not been

well-documented in the literature.<sup>8</sup> This equipment offers some advantages—such as better cooling, access, and visibility—over high-speed rotational burs.<sup>10</sup> As observed in Figure 10, even when a CVD bur in an ultrasonic handpiece touches the gingiva, the gingival tissue sustains less damage (due to the unidirectional oscillating movement) than that produced by a high-speed rotational bur. This results in a more precise finish with less noise and less patient discomfort. Other advantages include extended bur durability and preservation of the healthy tooth structure for conservative cavity preparations.<sup>8</sup>

While CVD burs have the same potential for removing sound dental structure as conventional high-speed burs, the procedure itself may require more time, which could be problematic in cases that require removing large amounts of dental structure or restorative material.<sup>9</sup> Although the slower procedure may result in greater precision, it does not mean that ultrasonic instruments do not cause any harm to the dental structure. The clinician should keep in mind that the safety and efficacy of ultrasonic instruments depend on tip angulation, the



Fig. 9. Minor damage to the gingival tissue after using the CVD diamond bur at a subgingival level.



Fig. 10. CVD diamond bur during the finishing procedure. Note that the bur is touching the gingiva while being activated by the ultrasonic handpiece.



Fig. 11. Anterior view of the direct adhesive restorations after finishing and polishing.



Fig. 12. The patient after smile harmony was re-established by the resin composite restoration.

level of power the device uses, lateral force, and the amount of time needed for the procedure.

The walking bleach technique was employed as part of an in-office technique. Although the discolored tooth was exposed to a high concentration of hydrogen peroxide, discoloration occurred again. A veneer was discussed with the patient, either placed with direct resin composite or indirect ceramics; a direct resin composite veneer was selected. Advantages to this procedure include the absence of the laboratorial phase (leading to lower costs), the opportunity to finish the case in a single session, and the opportunity for recontouring and re-polishing. In addition, studies have demonstrated the clinical durability of resin composite materials.<sup>11,12</sup> When selecting a treatment option, it is also important to consider the disadvantages of the proposed technique, such as the diminished color stability of resin composites.<sup>2</sup>

In the present case report, although the tooth was prepared for a veneer, the previous Class IV restoration was repaired rather than replaced, as it was believed to have good adhesion and its color matched those of the adjacent teeth. After opening

a small diastema at the mesial region of the left maxillary central incisor (to correct the morphologic asymmetry), a direct veneer was placed on the right maxillary central incisor. No preparations were placed on the dental structure.

Endodontically treated teeth are jeopardized biomechanically, and fiber-reinforced posts may be indicated to ensure favorable stress distribution.<sup>13</sup> However, no post was used in the present case, a decision based on the great amount of remaining tooth structure, particularly at the marginal ridges.

## Summary

Whenever the margins of a restoration are close to the gingival margin (as with veneers), it is important that appropriate finishing and polishing procedures are performed. Excess resin composite at the gingival margin of the veneer makes the restoration more prone to accumulate plaque and pick up staining from the consumption of coffee, tea, or red wine. Increased plaque retention could lead to periodontal problems as well as recurrent caries. Based on the present case report, CVD diamond burs cause less damage to the gingival margins than high-speed rotational burs.

## Author information

Drs. Furuse and Zielak are professors, Master of Science Program, Clinical Dentistry, Positivo University, Curitiba, PR, Brazil. Dr. Cunha is a private clinician in Brasilia, DF, Brazil. Drs. Runnacles and Pirolo are private clinicians in Curitiba, PR, Brazil.

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Clarity of objectives.....	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Clarity of exercise questions .....	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Relevance of exercise questions.....	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Did this exercise achieve its objectives?.....	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
Did this article present new information?.....	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
How much time did it take you to complete this exercise?.....	_____ mins	_____ mins	_____ mins

# Effect of chemical cleaning agents on the flexural strength of acrylic and hard denture line resins

Sabrina Alessandra Rodrigues, DDS, MSD ▪ Juliana Maria Costa Nunez Pantoja, DDS, MSD, PhD  
 Jessica Mie Ferreira Koyama Takahashi, DDS, MSD, PhD ▪ Rafael Leonardo Xediek Consani, DDS, MSD, PhD  
 Marcelo Ferraz Mesquita, DDS, MSD, PhD

This study sought to evaluate the disinfectants, Efferdent (EF) and 0.5% sodium hypochlorite (SH), and their effects on the flexural strength and modulus of elasticity of the hard denture liners, Kooliner (K) and New Truliner (NT), and a thermoacrylic resin, QC-20. Ninety specimens were made (50 mm x 10 mm x 3 mm) and divided into 9 groups ( $n = 10$ ). The 3 control groups were Group 1: QC-20 without disinfection cycles, Group 2: K, and Group 3: NT. The 6 experimental groups were Group 4: QC-20 in EF, Group 5: K in EF, Group 6: NT in EF, Group 7: QC-20 in SH, Group 8: K in SH, and Group 9: NT in SH.

Specimens were subjected to 360 cycles of disinfection involving 35-minute cycles of immersion in cleaning solutions. The materials' flexural strength and modulus of elasticity were determined using a universal testing machine at a 5 mm/minute speed of compression. The data were subjected to ANOVA, Tukey, Kruskal-Wallis, and Dunn tests ( $\alpha = 0.05$ ).

Regardless of the disinfection method used, the NT hard denture liner showed the lowest flexural strength values ( $P < 0.05$ ) and modulus of elasticity ( $P < 0.0001$ ) compared to K and QC-20. However, flexural strength values increased after applying SH and EF ( $P < 0.05$ ). QC-20 showed a higher modulus of elasticity ( $P < 0.033$ ), which increased after EF was applied ( $P = 0.005$ ). It can be concluded that the disinfection methods changed the mechanical properties of the tested materials.

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Removable prostheses can become unstable after long periods of use, due to continuous reabsorption of the osseous alveolar flange, which promotes loss of adaptation for the prosthesis on the mucosa. As a result, it is necessary to rebase the prosthesis, which improves the adaptation and distribution of loads.<sup>1,2</sup>

Currently, the base of a prosthesis can be relined directly in the mouth by using autopolymerized relines, or indirectly, by using thermopolymerized resins.<sup>3</sup> For the direct procedure, it is necessary to use a hard autopolymerizing or resilient resin denture reliner material. The resilient materials offer greater patient comfort; however, they also offer unfavorable mechanical and physical properties. The materials' resilience and superficial characteristics hamper cleaning.<sup>4</sup>

Nevertheless, rigid liners are physically and mechanically superior compared to resilient liners.<sup>5-7</sup> They contain methacrylate monomers and polymers—in place of the methyl methacrylate and polymethylmethacrylate (PMMA) found in autopolymerized resins—to control the temperature and time of material polymerization, thus reducing oral tissue irritation at the time of direct relining.<sup>4,8</sup>

According to the literature, thermopolymerized acrylic resins possess greater flexural resistance and modulus of elasticity compared to autopolymerized reliners, due to the higher quantity of residual monomer in autopolymerized acrylic resins.<sup>5,9-11</sup> This monomer residue stays on the base of a prosthesis for many years, which can affect the dentures' mechanical properties.<sup>1,9,12-14</sup>

Cleaning the prosthesis is a way to control microbial biofilm formation, which is essential for the maintenance of oral health. Oral health can be precarious for those who wear removable partial prostheses.<sup>15</sup> However, cleaning a prosthesis may affect the mechanical properties of the reliner materials and acrylic resin.<sup>16</sup>

Several methods of disinfection have been utilized over the years, and involve either mechanical appliances (such as brushing or ultrasonics) or chemicals (such as peroxides and hypochlorite).<sup>17</sup> Many patients (particularly the elderly) may find it difficult to implement an efficient mechanical method of disinfection.<sup>18</sup> In such cases, chemical cleaning agents should be used.

Sodium hypochlorite (SH) has a wide antimicrobial spectrum, and is economical and easy to handle. However, it can damage some materials, and even corrode metal frameworks, resulting in skin and

mucosal irritation.<sup>19</sup> Alkaline peroxides are less effective at removing broad spectrum microbial deposits and spots.<sup>20</sup> The action of alkaline peroxides on the prosthesis' components may cause such deleterious effects as a change in color or increased surface roughness.<sup>21</sup>

Several studies have assessed physical changes and antimicrobial effects following the chemical disinfection of resilient reliner materials.<sup>2,5,9,16,22</sup> Studies concerning changes in mechanical properties (particularly for rigid reliner materials) are scarce.<sup>3,5-7,23</sup> The present study evaluates the effect of the chemical cleaning agents on the flexural strengths and modulus of elasticity of two hard denture liners and a thermopolymerized acrylic resin.

## Materials and methods

This study tested two hard reliner materials—Kooliner (K) (GC America, Inc.) and New Truliner (NT) (Harry J. Bosworth Co.)—and a thermoacrylic resin (QC-20, DENTSPLY Caulk), in addition to two cleaning chemicals, SH 0.5% (Proderma) and Efferdent (EF) (Prestige Brands Holdings, Inc.).

Three rectangular metal matrices (50 mm x 10 mm x 3 mm) were lined, positioned, and fixed with cyanoacrylate-based



Fig. 1. A rectangular matrix is fixed onto a No. 6 metal flask.

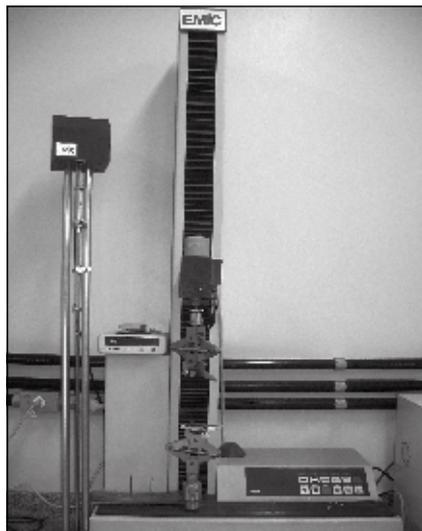


Fig. 2. Hydraulic press used for molds.

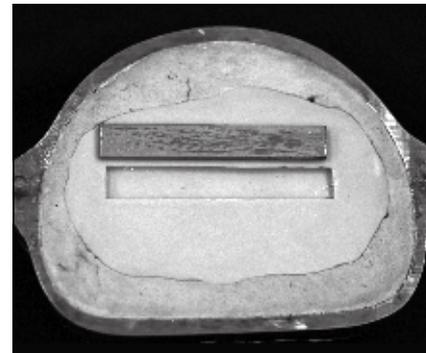


Fig. 3. A rectangular metal matrix in a silicone mold.

adhesive (Loctite 495 Super Bonder, Henkel Corporation) in a No. 6 metal flask (Fig. 1).<sup>22,23</sup> Next, the metal matrices were molded with silicone (Zetalabor, Zhermack, Inc.). A counter-flask was placed on the metal flask, filled with Type III dental stone, and subjected to 1 hour of pressure with a hydraulic press at 2440 kPa (Fig. 2) (EMIC, Equipamentos e Sistemas de Ensaio, LTDA.). After gypsum crystallization, the flask was opened and the rectangular metal matrices were removed from the silicone, leaving the mold form (Fig. 3).<sup>24</sup>

The acrylic resin was manipulated according to the manufacturer's instructions and placed in the interior of the silicone mold. The muffle was compressed slowly with the hydraulic press until pressure reached 2440 kPa; at that point, it was placed in a press staple and taken to a stage of thermopolymerization while immersed in water (20 minutes at 100°C). After immersion, the flask was cooled before deflasking.<sup>25</sup>

Kooliner (K) and New Truliner (NT) were made according to manufacturer instructions: for K, 15 mL of polymer: 6 mL of monomer; for NT, using the 1:1 bottles supplied by the manufacturer. The materials were poured into the molds and placed in the hydraulic press until a pressure of 976 kPa was achieved. After polymerization, the flask was opened, and the excess material was removed.

The specimens were finished and polished using flat-mounted 180, 200, 400, and 600 grit sandpaper (Buehler Ltd.), with wear controlled by digital calipers (Starrett), with an accuracy of 0.01 mm.<sup>23,24</sup> After this procedure, the samples were stored in distilled water (at 37°C) for 1 week. Next, the disinfection process was performed by immersing samples in SH or EF for 35-minute cycles, which were repeated 360 times.

Ninety specimens were prepared and separated into 9 groups (n = 10). The 3 control groups were Group 1: QC-20 without disinfection cycles, Group 2: K, and Group 3: NT. The 6 experimental groups were Group 4: QC-20 in EF, Group 5: K in EF, Group 6: NT in EF, Group 7: QC-20 in SH, Group 8: K in SH, and Group 9: NT in SH.

The samples were tested in a universal testing machine, at a constant speed of 5 mm/minute.<sup>24</sup> The resulting flexural strengths and modulus of elasticity were subjected to ANOVA, Tukey, Kruskal-Wallis, and Dunn ( $\alpha = 0.05$ ) tests.

## Results

The elastic modulus values in this study were subjected to ANOVA and Tukey ( $\alpha = 0.05$ ) tests, to allow for comparisons between groups. Meanwhile, the flexural strength values were subjected

to nonparametric statistical analysis using the Kruskal-Wallis test followed by Dunn's test ( $\alpha = 0.05$ ).

The Table shows that regardless of the disinfection treatments, the flexural modulus ( $P < 0.05$ ), and flexural strength ( $P < 0.05$ ) of NT was lower, compared to K and QC-20. However, after disinfection with EF and SH, only NT demonstrated an increase in flexural strength. There were no differences between QC-20 and K in terms of strength (MPa) after disinfection with SH or EF. However, samples disinfected with EF demonstrated an increase in elastic modulus, indicating an increase in the material's strength after disinfection. QC-20 showed the highest modulus, followed by K.

## Discussion

The hard reliners tested in this study showed lower flexural strengths and modulus of elasticity compared to the acrylic resin, regardless of the disinfection treatment (see Table). Studies have shown that flexural strength values are lower in self-curing resins compared to thermopolymerized resins.<sup>5,12,26-28</sup> This lower flexural strength may be due to the material's composition, which is similar but not identical to conventional PMMA resin, the basis of methyl methacrylate. The hard self-curing reliners contain

**Table. Median flexural strength and elastic modulus (both in MPa) of tested materials following disinfection.**

	Materials	Disinfection (SD)		
		Control	EF	SH
Strength	QC-20	2.36 (0.54) Aa	3.09 (0.67) Aa	2.68 (0.60) Aa
	K	2.25 (0.41) Aa	2.08 (0.30) Aa	2.11 (0.30) Aa
	NT	0.54 (0.15) Bb	0.78 (0.19) Ab	0.87 (0.12) Ab
Elastic modulus	QC-20	31.14 (6.82) Ba	41.35 (8.60) Aa	36.00 (8.38) ABa
	K	29.40 (5.95) Aa	27.47 (5.53) Ab	27.37 (4.48) Ab
	NT	7.75 (2.40) Ab	11.61 (3.65) Ac	11.43 (1.44) Ac

Flexural strength followed by distinct letters (uppercase horizontal/lowercase vertical, comparing material within the treatments) differs from Kruskal-Wallis test and Dunn test ( $P \leq 0.05$ ). Modulus of elasticity followed by distinct letters (uppercase horizontal/lowercase vertical, comparing material within the treatments) differ by Tukey's test ( $P \leq 0.05$ ).

PMMA both in its powder form and in its liquid forms—butyl methacrylate, isobutyl methacrylate or 1,6-hexanediol dimethacrylate.<sup>5,16,29-32</sup> These reagents provide time and temperature controls, which are important for self-curing, however, they also affect the materials' physical and mechanical properties.<sup>3</sup> The hard relining materials also contain more monomers compared to thermopolymerized conventional resins, which decrease the polymer's intermolecular forces, causing a plasticizing effect that causes these materials to undergo large deformation upon application of force and also has a negative effect on the mechanical properties.<sup>1-3</sup>

Among the relining materials, K showed higher flexural strength and elastic modulus than NT, regardless of the method of disinfection. This difference can be explained by the composition of these materials.<sup>3</sup> NT has a monomer that contains dibutyl phthalate.<sup>5-7,31</sup> The presence of phthalate molecules gives the NT material great flexibility and reduced resistance to bending.<sup>4</sup> The changes in the materials' mechanical properties may also be due to unstable behavior when immersed in saliva, water, or chemical disinfection solutions.<sup>18</sup> When these materials are immersed in such environments, a high sorption and solubility may result in swelling, distortion, and hardening.<sup>33</sup>

This hardening results from the leaching of plasticizers (known as *phthalates*) and aromatic esters of carboxylic acids, which

are present in greater quantity in resilient materials compared to prosthesis materials and hard relines.<sup>5,6,34</sup>

Based on the findings of a study by Davenport et al, it is possible that leaching may have occurred in this study, despite the small amount of plasticizers in each resin, which would explain the increased modulus of elasticity for QC-20 and NT's resistance to bending.<sup>35</sup> Additional research that subjects these rigid liners to the action of chemical cleaning agents is necessary to confirm this theory.

According to some studies, SH and EF did not change the mechanical properties of these rigid lining materials, while other studies reported decreased mechanical properties.<sup>16,35-37</sup> As a result, there is no consensus in the literature regarding how chemical cleaning agents might affect the mechanical properties of rigid relining materials and conventional thermoacrylic resin.<sup>5,38</sup> Arima et al reported that acrylic materials with cross-linking agents demonstrated greater stability in terms of the modulus of elasticity when stored in water or in chemical cleaning agents.<sup>6</sup> However, QC-20, K, and NT do not contain such agents.<sup>39</sup>

## Summary

Based on the results of the present study, both disinfection techniques increased the elasticity of QC-20, while disinfection with EF resulted in a larger increase. In terms of flexural strength, only NT

samples increased in the 2 disinfected groups; however, flexural strength values of NT samples were still smaller than those treated with QC-20 and K. Additional research is required to evaluate the long term effects of these chemical agents on the mechanical properties of these prostheses.

## Author information

Drs. Rodrigues and Pantoja are postdoctoral candidates, and Drs. Consani and Mesquita are professors, Department of Prosthesis and Periodontology, Dental College of Piracicaba, Sao Paulo, Brazil. Dr. Takahashi is a professor, Prosthodontics, Health Sciences Graduate School, Amazonas State University, Manaus, Amazonas, Brazil.

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## Manufacturers

- Buehler Ltd., Lake Bluff, IL  
800.283.4537, [www.buehler.com](http://www.buehler.com)
- DENTSPLY Caulk, Milford, DE  
800.532.2855, [www.caulk.com](http://www.caulk.com)
- EMIC Equipamentos e Sistemas de Ensaio, LTDA., Brazil  
55.42.3035.9400, [www.emic.com.br](http://www.emic.com.br)
- GC America, Inc., Alsip, IL  
800.323.7063, [www.gcamerica.com](http://www.gcamerica.com)
- Harry J. Bosworth Co., Skokie, IL  
800.323.4352, [www.bosworth.com](http://www.bosworth.com)
- Henkel Corporation, Rocky Hill, CT  
860.571.5100, [www.henkelna.com](http://www.henkelna.com)
- Prestige Brands Holdings, Inc., Irvington, NY  
800.443.4908, [www.prestigebrands.com](http://www.prestigebrands.com)
- Proderma, Sao Paulo, Brazil  
51.3595.3397, [www.proderma.com.br](http://www.proderma.com.br)
- Starrett, Athol, MA  
978.249.3551, [www.starrett.com](http://www.starrett.com)
- Zhermack, Inc., Eatontown, NJ  
732.389.8540, [zhermack.com](http://zhermack.com)

# Orthodontic extrusion: diagnosis and treatment with CBCT in a pediatric patient

Rakesh N. Bahadure, MDS ▪ Nilima Thosar, MDS ▪ Monika Khubchandani, MDS

Traumatic injury to a primary tooth can affect the underlying permanent tooth germ, and may result in a malformed, hypoplastic crown or root. The degree and nature of malformation depends on the injury. Most trauma cases can be diagnosed using conventional 2-dimensional radiographs, but some cases may benefit from more advanced 3-dimensional imaging such as cone beam computed tomography (CBCT).

This report describes the use of CBCT in the diagnosis and treatment planning of a case in which a 10-year-old girl reported with an impacted, recessed central incisor. The tooth was deformed due to trauma at an early age. Conventional 2-dimensional occlusal and periapical radiographs seemed to indicate that the root had almost completely resorbed.

This implied that the optimal treatment plan would be the extraction of the central incisor and, later, the placement of an implant with a crown or bridge. However, a 3-dimensional CBCT radiographic examination showed that the tooth root was long and had enough of a crown-to-root ratio to anchor the tooth. The CBCT examination compelled the treating dentists to maintain the central incisor by orthodontically extruding the tooth and then rebuilding it with a bonded composite restoration.

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**T**raumatic injuries of the primary dentition occur due to falls, accidents, sports injuries, and physical abuse. Several developmental alterations—such as discoloration, hypoplasia, crown dilaceration, root angulation or dilaceration, sequestration of permanent tooth buds, and disturbance in eruption—have been reported in permanent teeth. The prevalence of traumatic injury in the primary dentition is 15%-30%, with injuries occurring mostly between the ages of 2-4 years.<sup>1,2</sup> The intrusion of a primary tooth is the most prevalent injury that can result in a disturbance to permanent teeth (18%-69%).<sup>3,4</sup>

## Case report

A 10-year-old girl reported with the chief complaint of an unerupted maxillary right central incisor and an unerupted maxillary right lateral incisor. The child's history revealed trauma at the age of 4 resulting in the intrusion of a deciduous tooth in the same region. The neighboring central incisor showed normal eruption.

With an initial, preoperative, conventional 2-dimensional occlusal radiograph, it was difficult to identify the root morphology, length, or position of the unerupted central incisor (Fig. 1). The

root appeared resorbed and blunted. This resulted in a preliminary assessment that the right maxillary central incisor may eventually require extraction, followed by placement of an implant or a bridge after sufficient growth and development of the maxilla and dentition.

However, it was decided to surgically expose and orthodontically extrude both the maxillary right central and maxillary right lateral incisor (Fig. 2). After this initial extrusion treatment, another 2-dimensional radiograph was taken to determine whether the root morphology of the central incisor would appear more obvious.



Fig. 1. A preoperative occlusal radiograph showing the impacted maxillary right central and lateral incisors.



Fig. 2. Surgical exposure of the impacted upper right central and lateral incisors and bracket placement for traction.



Fig. 3. A periapical radiograph taken after an initial orthodontic extrusion showing the unclear root morphology of the maxillary right central incisor.



Fig. 4. An occlusal radiograph taken after an initial orthodontic extrusion showing the unclear root morphology of the maxillary right central incisor.



Fig. 5. A 3-dimensional CBCT image showing the clear zigzag morphology of the root of the maxillary right central incisor.



Fig. 6. A postoperative clinical photo of the maxillary right central incisor after completion of orthodontic extrusion treatment and a bonded composite restoration.

After orthodontic traction, however, the morphology of the central incisor root was still unclear on both the post-traction 2-dimensional periapical radiograph (Fig. 3) and the occlusal radiograph (Fig. 4). This implied that the optimal treatment plan would be to extract the central incisor, and later place an implant, crown, or bridge.

After the initial treatment of orthodontic extrusion, it was decided to image the maxillary right central incisor using a 3-dimensional CBCT radiograph to obtain a clearer image of the root morphology. The CBCT examination indicated that the root was sufficiently intact, showing a zigzag root curvature (Fig. 5). The occlusal aspect of the root may have been superimposed on the apical aspect of

the root on the 2-dimensional radiographs. The CBCT image also showed there was probably enough periodontal ligament surface area to provide an adequate crown-to-root ratio to retain the tooth. In addition, the zigzag curvature would help to mechanically interlock the root into the alveolar bone, improving tooth anchorage.

The 3-dimensional CBCT image confirmed the feasibility of the orthodontic extrusion treatment plan. The plan was to retain the tooth, surgically expose it, extrude it orthodontically, and then rebuild it with a bonded composite restoration. Since the root was naturally short, it was important not to let it supra-erupt via extrusion of a large amount of the root, as this would negatively affect

the crown-to-root ratio that would result from the amount of root remaining in the alveolus. Hence, the orthodontist limited the extrusion of the central incisor, such that its incisal edge would be positioned 2.5 mm shorter than the incisal edge of the neighboring central incisor. Bonded fiber-reinforced composite (Original Ribbond, Ribbond) was used to rebuild the extruded incisor to match the incisal level of the neighboring incisor (Fig. 6).

A 1-year follow-up demonstrated the success of this treatment plan. At approximately 18 years of age (after most growth and development has occurred), a permanent crown, implant, or bridge restoration may be considered if the bonding ultimately fails.

## Discussion

Various stages of tooth germ development occur at various ages. If a traumatic injury occurs at an age when a part of the permanent tooth bud is still developing, it may result in a deformed tooth. The formation of the tooth germ of a permanent upper central incisor occurs at 20 weeks of gestation, and calcification begins at 3-4 months of age.<sup>5</sup> The crown of the central incisor tends to calcify during early childhood. The completion of root formation occurs later, approximately 2 to 3 years after its eruption into the oral cavity. In the present case, trauma to the maxilla at 4 years of age resulted in deformed root formation (a zigzag shape), while the crown was of a relatively normal morphology.

Intrusive injury caused by apical displacement of a primary tooth root may affect development of the permanent tooth by either altering the secretory phase of the ameloblasts, or in subsequent stages by affecting the root formation process.<sup>2,4</sup>

Some authors suggest that a 3-dimensional CBCT examination shows higher sensitivity and specificity for detecting root morphology and other root features, such as vertical root fractures, when compared to a conventional 2-dimensional radiographic examination.<sup>6</sup> In this case report, 2-dimensional radiographs, taken both preoperatively and after an initial orthodontic extrusion treatment, showed presence of a small and deformed root. This implied that further orthodontic extrusion should be discontinued and the tooth should be extracted. In contrast, a

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CBCT examination taken after the initial orthodontic extrusion showed a zigzag root morphology, with an adequate crown-to-root ratio, and mechanical anchorage into the alveolar bone. This justified the treatment plan to maintain the tooth, and use orthodontic extrusion and bonding to restore it to its normal form and function.

### Conclusion

CBCT, due to its 3-dimensional capabilities, has many applications in dentistry. This report proves that in this orthodontic extrusion case, CBCT assisted in a better diagnosis and treatment plan than conventional radiographic methods indicated.

### Author information

Drs. Bahadure and Khubchandani are assistant professors, Department of Pedodontics & Preventive Dentistry, Government Dental College & Hospital Nagpur, Maharashtra, India, where Dr. Thosar is a professor.

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# Effect of whitening toothpaste on superficial roughness of composite resin

Natalia Ventura da Cas, DDS ▪ Gabrielle Rodrigues Ruat, DDS, MS ▪ Renata Pla Rizzolo Bueno, DDS, MS ▪ Raquel Pachaly, DDS, MS  
Roselaine Terezinha Pozzobon, DDS, MS, PhD

This study sought to evaluate the effect of different toothpastes with whitening action on the average surface roughness (Ra) of a micro-hybrid composite resin. Twenty-five specimens of composite resin were prepared and distributed randomly among 5 experimental groups ( $n = 5$ ). Groups 1-3 were treated with whitening toothpastes: Close-Up Extra Whitening, Colgate Ultra White, and Colgate Total 12 Whitening. Group 4 was a negative control group (with samples brushed with deionized water), and Group 5 was a positive control group (with samples brushed using a non-whitening toothpaste). A profilometer was used to determine Ra before and after brushing. A simulated brushing machine was used for all groups, providing horizontal back and forth movement with an amplitude of 3.8 cm applying an axial load of 200 g

and a speed of 356 rpm, totaling 20,000 cycles. To determine the Ra in each specimen, 6 readings were taken at various positions before and after brushing. The results were submitted to variance analyses and Tukey's test ( $P < 0.05$ ).

Groups 1, 2, 3, and 5 demonstrated statistically significant differences between initial and final averages. Based on these results, it was determined that brushing with toothpaste, regardless of formulation, significantly increased the Ra of the resin composite evaluated in this study.

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Key words: composite resins, toothpaste, tooth

A person's physical appearance and emotional state can be strongly affected by their smile and the color of their teeth. Therefore, a large number of toothpastes with whitening action in various formulations have been introduced to the market.<sup>1,2</sup> Changes in tooth color can affect both teeth and esthetic restorations. These changes have multifactorial causes that involve external factors, such as plaque accumulation, surface degradation due to the penetration of coloring agents, and micromorphological aspects of the tooth surface and restorative materials, which may lead to degradation of the organic resin matrix and surface roughness (Ra).<sup>3-6</sup> Degradation of the composite resins in the oral environment can result from chemical or abrasive action. For that reason, the impact of brushing must be considered when evaluating the prognosis and durability of composite restorations. Hygiene procedures should not contribute to the formation of large superficial defects, which would result in increased roughness, biofilm retention, and staining.<sup>1,7-11</sup>

The use of toothpastes that promote whitening by removing or controlling extrinsic stains on the tooth surface through abrasion has become common.<sup>12,13</sup> Typically, hydrated silica, calcium carbonate, dehydrated dicalcium phosphate, calcium pyrophosphate, alumina, sodium bicarbonate, and perlite

are the abrasive agents used in whitening toothpastes.<sup>2,8,12-16</sup>

Restorative materials with surface roughness would have a negative effect on the aesthetic appearance of the restorations (that is, staining and tearing) and lead to greater accumulation of biofilm, which could in turn result in cavities and periodontal disease.<sup>17</sup>

Comparatively few studies have discussed the long-term effect of whitening toothpaste used without prescription or professional supervision on the Ra of resin composite restorations. Since the abrasive action of brushing is considered a contributing factor to the disintegration of dental materials, an evaluation by means of simulated toothbrushing in vitro may be a parameter to evaluate the ability of a restorative material to resist deterioration, prevent staining, and maintain luster and smoothness.<sup>18-20</sup> This study sought to evaluate the in vitro effect of different whitening toothpastes on the Ra of a composite resin.

## Materials and methods

A microhybrid composite resin (Four Seasons enamel shade A2, Ivoclar Vivadent AG), was submitted to the action of 3 toothpastes with different bleaching formulations (Table 1): Close-Up Extra Whitening (Unilever) (Group 1), Colgate Ultra White (Colgate-Palmolive Company) (Group 2) and Colgate

Total 12 Whitening (Colgate-Palmolive Company) (Group 3). There were also 2 control groups: Group 4 was a negative control group, as samples were brushed using only deionized water, while Group 5 was a positive control group, using a common nonwhitening toothpaste (Sorriso, Colgate-Palmolive Company).

The response variable was the average Ra, determined using a digital profilometer (Surftest SJ-201P, Mitutoyo America Corporation). To determine the roughness, the diamond tip of the profilometer went through the test specimen at a constant speed of 0.25 mm/second using a force of 4 mN. The cut-off value was adjusted to operate at 0.25  $\mu\text{m}$  and a Ra was characterized by the arithmetic mean of the highest and lowest measurements found in a central line along the evaluated area measured in  $\mu\text{m}$ . Six readings were taken on each specimen in the x- and y-axis directions before and after brushing. The average of these readings was used for statistical analysis.

## Preparation of specimens

Twenty-five specimens of composite shade A2 (Four Seasons, Ivoclar Vivadent AG) were prepared. Each specimen was made from a bi-parted matrix (10 mm in diameter with a 2 mm deep central circular perforation) and placed on a glass plate. The circular perforation was filled with a single increment of composite resin inserted

**Table 1. Compositions of all toothpastes used in the present study, based on the packaging label provided with each product.**

Group (n = 5)	Toothpaste	Composition
1	Close-Up Extra Whitening	Calcium carbonate, sorbitol, water, silica sodium lauryl sulfate, flavor, sodium monofluorophosphate (1,450 ppm fluoride), trisodium phosphate, titanium dioxide, cellulose gum, perlite, sodium saccharine, formaldehyde, CI 74160
2	Colgate Ultra White	1,450 ppm fluoride, sorbitol, calcium carbonate, aluminum oxide, carboxymethylcellulose, sodium saccharin, sodium lauryl sulphate, sodium silicate, aroma, methylparaben, water, sodium monofluorophosphate
3	Colgate Total 12 Whitening	Sodium fluoride (1,450 ppm fluoride), 0.3% triclosan, sodium lauryl sulfate, sorbitol, hydrated silica, gantrez, sodium saccharine, aromatic composition, dyes, water, triclosan, fluoride, carrageenan, sodium hydroxide
4	Deionized Water (negative control)	n/a
5	Sorriso (positive control)	Sorbitol, water, hydrated silica, sodium lauryl sulphate, PEG-12, aroma, cellulose, gantrez, sodium saccharin, fluoride, CI 77891, CI 74160, sodium fluoride (1,100 ppm fluoride)

**Table 2. Variations in Ra among the 5 experimental groups (n = 5)**

Group	Variations in Ra (SD)	
	A	B
1		0.1360 (0.3870) B
2		0.1143 (0.8494) B
3		0.1537 (0.5612) B
4	0.0043 (0.1164) A	
5		0.1877 (0.7204) B

Different letters indicate statistically significant differences.

using a composite spatula. The resin was placed on a strip polyester matrix and covered by a glass plate 20 mm thick (accommodating both the matrix and the overflow of excess resin), which received a 500 g load for 10 seconds. Photopolymerization of the resin was performed over three 20-second periods, using a curing light (Dabi Atlante) at 600 mW/cm<sup>2</sup>. The first exposure occurred when the glass plate was placed on the specimen, the second after the removal of the glass plate, and the third after the removal of the polyester matrix. Once removed from the matrix, all of the specimens were stored in deionized water at 37°C and polished after 24 hours (APL-4 polisher, Arotec SA) using 600, 1200, and 2500 grit sandpaper (3M ESPE) to remove the surface layer (which is rich in organic matrix) and standardize the surface texture. At that point, specimens were immersed in deionized water, kept in an oven (at 37°C) for 24 hours, and divided randomly into 5 experimental groups for the initial Ra readings (Rai).

**Evaluation of Rai values**

The Surfrest SJ-201P was used to measure the Rai values of the specimens. To facilitate handling during readings of surface

roughness and to avoid manual contact with the surfaces to be evaluated, the specimens were fixated in a glass plate by a support. Six measurements were performed on the perpendicular *x* and *y* axes of each specimen, which generated an arithmetic average that was considered to be the specimen's Rai value. After the readings were complete, the specimens were stored for 24 hours in deionized water (at 37°C) until the simulated toothbrushing began.

**Simulated toothbrushing procedure**

The simulated toothbrushing of specimens was performed in a controlled toothbrushing simulation machine, designed and conceived at the Federal University of Santa Maria. This machine utilizes an engine and pulleys to produce back and forth movements of 10 arms to which toothbrushes (Oral-B Indicator Plus, Procter & Gamble) were affixed. The machine was set to perform along a horizontal path of 3.8 cm (1.5 in.) on each specimen, at a speed of 356 rpm, applying an axial load of 200 g to simulate the force used during normal oral hygiene procedures.<sup>21,22</sup> 20,000 cycles were performed and registered in a cycle counter, corresponding to two years of brushing,

as based on standards introduced by Goldstein & Lerner.<sup>23</sup> Once the tests were completed, the specimens were removed from the brushing machine, washed thoroughly with air/water spray, and then stored in deionized water (at 37°C) for 24 hours until the final surface roughness (Raf) reading. The Raf was determined in the same way as the Rai, wherein 6 measurements were performed on the perpendicular *x* and *y* axes of each specimen; that generated an arithmetic average, which was then considered each specimen's Raf.

**Statistical analysis**

The nominal Ra values were tabulated and analyzed using descriptive statistical software (SPSS version 18.0, IBM Corporation). The distribution normality in each group was checked by using the Shapiro-Wilk test, and the homoscedacity between groups was checked using the Levene test. The data of surface roughness (Ra) were compared among the 5 experimental groups in each experimental period using ANOVA and Tukey test (*P* < 0.05). Variation in roughness was calculated and this variable was then compared with the 5 experimental groups by the same tests mentioned above (Table 2).

## Results

In analyzing the data in Table 2, which shows the variation of the average roughness (Ra) in the 5 experimental groups, Groups 1-3 and 5 had similar increases in roughness of the resin. The only significant difference in Ra occurred in Group 4 (negative control), where brushing was performed using only deionized water.

## Discussion

The surfaces of restorative materials in the oral cavity are subjected to a variety of factors that can influence surface quality. Oral hygiene procedures can increase the Ra of restorative materials, thus promoting bacterial growth and staining.<sup>17</sup> The present study tested how brushing with a toothpaste with whitening action affected the Ra of a microhybrid composite resin.

For the groups that brushed with different toothpastes, there were significant (although statistically similar) differences between the mean Rai and Raf values. These Ra values increased similarly, regardless of the toothpaste. However, brushing with deionized water only failed to significantly alter the Ra of Group 4. These results are similar to those reported by Tellefsen et al, who found that toothbrushing alone did not have the capability to promote a significant increase in roughness, but that brushing with toothpaste could affect surface texture due to the retention of the abrasive agent.<sup>23</sup> In addition, Goldstein & Lerner reported that brushing with water resulted in lower Ra for composite resin compared to brushing with toothpaste.<sup>24</sup>

The presence of abrasives in the composition of toothpastes is responsible for brushing-related abrasion.<sup>25</sup> Hydrated silica is the only abrasive component in both Sorriso and Colgate Total 12 Whitening, while the others have different abrasive agents in their composition (such as calcium carbonate, alumina, sodium silicate, perlite, and silica). However, despite this difference in composition, the behavior of all 4 toothpastes in this study was the same. The increase in resin Ra may be due to the abrasion of the organic matrix and the subsequent exposure of particles.

According to Amaral et al, larger abrasive particles means more abrasion from the toothpaste; however, silica is more abrasive than calcium carbonate when their particles are the same size.<sup>1</sup> As a result, brushing

composite with a toothpaste containing alumina, silica, and calcium carbonate produces a lower Ra than toothpastes containing sodium bicarbonate.<sup>1</sup> The present study showed contrasting results, as the Ra of composite resins increased similarly among toothpastes containing different abrasives. Methodological differences may have contributed to this disparity.

A 2010 study by da Costa et al concluded that low-abrasion dentifrices produced smaller changes in the Ra of composite resins after brushing, while the present study reported similar results after brushing with any of 4 different toothpastes, regardless of their abrasive qualities.<sup>20</sup> Heintze et al evaluated the changes in Ra after simulated brushing of 9 different composites in relation to brushing time and load in vitro.<sup>26</sup> In general, hybrid composites show the highest increase in Ra values.

It is worth noting that the Colgate Total 12 Whitening toothpaste has the same abrasive (hydrated silica) as Sorriso, the non-whitening toothpaste; however, the former costs on average 3 times more than the latter.

Previous studies concerning the long-term effects of different toothpastes on the Ra of composite resins show mixed and inconclusive results. If the surface characteristics of a restorative material are considered to be important for maintaining their optical and esthetic properties and the health of the periodontal tissue, additional studies should be conducted so that the proper dentifrices may be recommended, based on scientific evidence.

## Conclusion

The results of the present study indicate that brushing with toothpaste, regardless of its formulation, significantly increased the Ra of the composite resin.

## Author information

Dr. Cas is a dental surgeon, Sistema Unico de Saude, Panara, Brazil. Dr. Ruat is a Master of Dental Science, Federal University of Santa Maria, Rio Grande do Sul, Brazil; where Dr. Bueno is a surgeon dentist, Brazilian Air Force, Canoas; Dr. Pachaly is a surgeon dentist, Brazilian Air Force, Santa Maria; and Dr. Pozzobon is an associate professor, Department of Restorative Dentistry, Odontology Course and Graduate Program.

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# Multiple oral radiopaque masses leading to Gardner's syndrome diagnosis

Aline Garcia Figueiredo Costa ▪ Rayana Ondina Biagioni Costa ▪ Lucinei Roberto de Oliveira, DDS, MSD, PhD  
Soraya de Mattos Camargo Grossmann, DDS, MSD, PhD

Gardner's syndrome, an autosomal dominant syndrome, is linked to familial adenomatous polyposis (FAP), which is known mainly as a colorectal disease. FAP also presents extracolonic as intestinal polyposis, multiple osteomas, cutaneous cysts, or fibromas. This article reports the case of a 66-year-old white woman who was referred to the Oral Medicine Clinic, School of Dentistry, Universidade Vale do Rio Verde, Brazil, for evaluation of multiple sclerotic, asymptomatic masses in the jaws that were observed in a routine periapical radiographic exam by a dentist. The patient presented with intestinal poliposis, periosteal

osteoma in the face, and fibromas and multiple endosteal osteomas in the maxilla, which are indications of Gardner's syndrome. The clinical differential diagnosis included multiple buccal exostoses, idiopathic osteosclerosis, cemento-osseous dysplasias, multiple odontomas, osteomas, and Gardner's syndrome. Patients with a suspected diagnosis of Gardner's syndrome should be referred to a dermatologist, have a colonoscopy performed, and be followed up by a dentist.

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A 66-year-old woman was referred to the Oral Medicine Clinic, School of Dentistry, Universidade Vale do Rio Verde, Brazil, for evaluation of multiple sclerotic masses in her maxilla and mandible (Fig 1). The alterations, observed in a routine periapical radiographic exam, presented as asymptomatic. An extraoral physical examination revealed a well circumscribed and sessile nodule located on the midline of the forehead (Fig. 2). The nodule was bony-hard on palpation, measuring 20 mm x 20 mm x 10 mm, and, according to the patient, had been present for approximately 4 years. The patient reported that a radiographic exam of this nodule was done previously

by an orthopedist who analyzed the radiograph and informed her that nothing needed to be done at that time. When an intraoral physical examination was performed, bilateral rows of multiple nodules (pink to light red) were observed on the vestibular alveolar ridge. The nodules measured approximately 3 mm x 5 mm x 2 mm, appeared to be well circumscribed and sessile, were of firm consistency when pressed, and were asymptomatic (Fig 3). The patient was completely edentulous and used dentures that were well adapted. A panoramic radiograph revealed multiple well-circumscribed ovoid radiopacities in the bilateral angle of the mandible, and in the left side of the posterior maxilla,

without presenting any prominent facial deformity (Fig. 4).

## Differential diagnoses

In accordance with these observations, the clinical differential diagnoses considered were multiple buccal exostoses, idiopathic osteosclerosis, cemento-osseous dysplasias, multiple odontomas, osteomas, and Gardner's syndrome.

*Multiple buccal exostoses* are bony protuberances that arise from the cortical plates that frequently affect the mouth. These exostoses usually occur in the late teens or early adult years.<sup>1</sup> Although their etiology remains unknown, it has been suggested that exostoses may be the result of a mild, chronic periosteal inflammation.

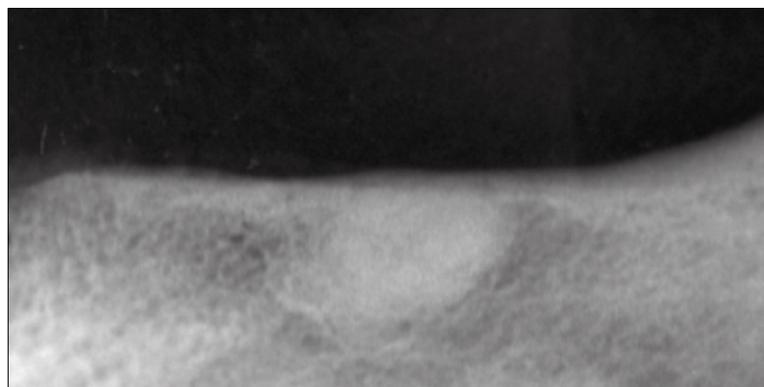


Fig. 1. A periapical radiograph showing a radiopaque ovoid mass located on right side of mandible.



Fig. 2. A well circumscribed and sessile nodule located on the midline of the forehead.



Fig. 3. Multiple nodules (pink to slightly red) located on the vestibular alveolar ridge.

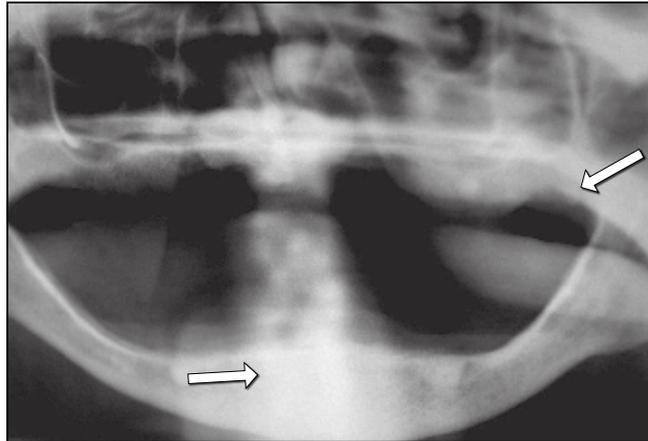


Fig. 4. Panoramic radiograph showing multiple well-circumscribed and ovoid radiopacities both in the bilateral angle of the mandible and in the left side of the posterior maxilla (arrows).

They present as a bilateral row of bony hard nodules of the alveolar ridges and are asymptomatic. A diagnosis of multiple buccal exostoses is based on clinical and radiographic findings. An additional biopsy for diagnosis is usually not recommended.<sup>2</sup> In our case, the patient's nodules in the mouth did not demonstrate the bony protuberances associated with multiple buccal exostoses.

The second diagnostic hypothesis was *idiopathic osteosclerosis*. This pathology consists of a focal area of increased radiodensity in bones. Its cause is unknown and cannot be associated with any inflammatory, dysplastic, neoplastic, or systemic disorders.<sup>3</sup> Clinically, the lesions are asymptomatic, without detectable cortical expansion, and are detected during routine radiographic examination.<sup>4</sup> Radiographically, idiopathic osteosclerosis presents as a well-defined elliptic radiodense mass, and no treatment is indicated.<sup>5</sup>

The next hypothesis was *cemento-osseous dysplasia*. It occurs in the tooth-bearing areas of the maxilla and mandible and is a common dental fibrous-osseous lesion in people of color.<sup>6</sup> Three subtypes of cemento-osseous dysplasia can be detected radiographically: focal, periapical, and florid. It is completely radiolucent until it forms into a radiopaque mass.<sup>7,8</sup> This case could be a florid subtype, although the patient was not a woman of color.<sup>9</sup>

Another possible diagnosis was *multiple odontomas*. These are the most common type of odontogenic tumors, and can be subdivided into *compound* and *complex* types.<sup>2,10</sup> The diagnosis usually occurs at approximately 14 years of age, on a routine radiograph. They are frequently observed in the maxilla, and are asymptomatic.<sup>11,12</sup> Complex odontoma may be radiographically confused with an osteoma or some other bony nodule, however, it appears as a circumscribed radiolucent nodule.<sup>13</sup> Odontomas should be locally excised, and have excellent prognoses.<sup>2</sup>

*Osteomas* were considered as a hypothetical diagnosis, because they consist mainly of craniofacial skeleton cells. An osteoma usually appears as a polypoid or sessile mass in young adults, and is generally asymptomatic.<sup>14</sup> Radiographically, an osteoma appears as a circumscribed sclerotic mass localized in the body of the mandible or condyle. Some types may result in facial deformity.<sup>15</sup> However, osteomas tend to be solitary growths, and when multiple osteomas are observed, as in this case, a diagnosis of Gardner's syndrome should be considered.<sup>16</sup>

*Gardner's syndrome*, a rare disorder, is considered a part of a spectrum of familial colorectal polyposis that may involve the skin, soft tissues, retina, skeletal system, and teeth.<sup>17,18</sup> Many of these extracolonic manifestations, such as multiple osteomas, can lead to the discovery of the syndrome.<sup>19,20</sup>

## Diagnosis and management

When asked about her intestinal history, the patient reported that she had been diagnosed with intestinal polyposis, which had been confirmed by an endoscopy. An excisional biopsy of a nodule from the alveolar ridge was obtained. H&E-stained sections revealed collagenized fibrous connective tissue with chronic inflammatory infiltrate. The diagnosis was a nonspecific inflammatory nodule. The postoperative course was uneventful. Considering all clinical, radiographic and histopathologic features, the final diagnosis was Gardner's syndrome. The patient returned after 1 month, at which time there was no evidence of recurrence or other alterations. A new panoramic radiograph demonstrated no osseous changes. The patient is in attendance with a gastroenterologist and dermatologist, and she is being followed up by our clinic.

## Discussion

Gardner's syndrome, identified in 1953, represents an autosomal dominant syndrome (on chromosome 5 or sporadic mutation) with nearly complete penetrance but markedly variable expressions.<sup>21</sup> This syndrome affects one in 8300 individuals and one in 7500 births in the United States.<sup>22,23</sup> Gardner's syndrome is linked to familial adenomatous polyposis, a colorectal disease where extracolonic features are prominent.<sup>17,18</sup>

Intestinal polyposis, multiple osteomas, cutaneous cysts, or fibromas are common features in patients with Gardner's syndrome.<sup>24</sup> Other findings include impacted or unerupted teeth, congenitally missing teeth, supernumerary teeth, hypercementosis, dentigerous cysts, fused roots of the first and second molars, long and tapered roots of posterior teeth, multiple caries, benign tumors (fibromas, lipomas, leiomyomas, neurofibromas), and carcinomas of the colon and rectum.<sup>25,26</sup> In order to make a preliminary diagnosis of Gardner's syndrome, the presence of multiple osteomas is required; the mandible is the most common site for these osteocytes, however, they may also be observed in the skull and in long bones.<sup>27</sup> Our case profiled a patient with intestinal poliposis, periosteal osteoma in the face, fibromas, and multiple endosteal osteomas in the maxillary, which resulted in a diagnosis of Gardner's syndrome.

### Conclusion

Multiple oral osteomas can precede the clinical and radiographic evidence of colonic polyposis or Gardner's syndrome, therefore, they can be considered sensitive markers for the disease.<sup>17</sup> The oral manifestations may be used by both the dentist and the gastroenterologist to help clinically identify the syndrome at an early age.<sup>18</sup> Ida et al suggested that patients with 3 to 6 oral osteomatous nodules should be further examined for the possibility of Gardner's syndrome.<sup>28</sup> A dental patient with a suspected diagnosis of Gardner's syndrome should be referred to a gastroenterologist and a colonoscopy should be performed. The patient should then schedule a follow-up dental appointment, as described in this case.<sup>29</sup>

### Author information

Ms. A. Costa and Ms. R. Costa are graduate students, School of Dentistry, Universidade Vale do Rio Verde, Brazil, where Drs. de Oliveira and Grossmann are professors, Department of Oral Pathology.

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# Facial pigmentation associated with amiodarone

Wilfredo Alejandro Gonzalez-Arriagada, DDS, MSc ▪ Alan Roger Santos Silva, DDS, PhD ▪ Pablo Agustin Vargas, DDS, PhD  
Oslei Paes de Almeida, DDS, PhD ▪ Marcio Ajudarte Lopes, DDS, PhD

Amiodarone is one of the most commonly used drugs for treatment of cardiac arrhythmia. Several undesirable effects are associated with its long-term use. This report describes the case of a 71-year-old female patient, with a diagnosis of cardiac arrhythmia, who presented with a stigmatizing blue-gray facial pigmentation and altered serum values of thyroid hormones associated with the intake of amiodarone. The patient was referred to her cardiologist. The aim of this report

is to increase clinicians' awareness about the potential adverse effects of this drug.

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**A**miodarone is a drug taken for the treatment of the heart condition, cardiac arrhythmia.<sup>1,2</sup> However, several adverse effects have been reported in patients taking amiodarone.<sup>3,4</sup> Two of the collateral effects of amiodarone—which are rarely seen, and mainly reported in elderly patients—are skin photosensitivity and blue-gray facial pigmentation.<sup>3,4</sup> The authors present a case report of a patient who developed extremely bluish facial pigmentation and thyroid dysfunction during the use of amiodarone for the treatment of cardiac arrhythmia. Emphasis was given on the diagnosis process, as well as to the differential diagnoses of this drug-related complication.

## Case report

A 71-year-old woman was referred to the Oral Diagnosis Clinic, Piracicaba Dental School, State University of Campinas,

Brazil, with the chief complaint of a nodule on the hard palate that had been present for approximately 7 years. The patient had a medical background of hypertension and cardiac arrhythmia, which had been treated with amiodarone over the last 3 years. The patient recounted that she took 400 mg daily in the first 15 months, and 200 mg daily thereafter. Head and neck physical examination revealed a distinct blue-gray pigmentation of the mid- and upper-thirds of the face, especially in the nose, zygomatic, and frontal regions (Fig. 1). According to the patient, this had had been noticeable for the last 18 months; when asked about the facial pigmentation, the patient reported that she was diagnosed with rosacea by her dermatologist, who treated her with tetracycline and sunblock lotion. She had been in treatment for 9 months without improvement. Intraorally, a pedunculated nodule was observed on

the hard palate, which presented a superficial area of bluish pigmentation (Fig. 2). Discreet areas of denture-related stomatitis were also noticed.

Laboratory blood tests showed altered hepatic and thyroid functions, with abnormal values for aminotransferase, T4, and TSH: AST/TGO = 38 U/L (ref. <31 U/L); T4 = 2.66 ng/dL (ref. 0.75 to 1.80 ng/dL); and TSH = 0.012 UIU/mL (ref. 0.350 to 5.500 UIU/m/L).

After examination, and with the provisional diagnosis of facial pigmentation associated with amiodarone, a skin biopsy was performed on the zygomatic region. H & E stain revealed an orthokeratinized stratified epithelium covering the dermis with evident signals of solar elastosis. A granular yellow-brownish pigmentation was observed inside histiocytes along the dermis, close to the blood vessels (Fig. 3). Fontana-Masson and Perls histochemical



Fig. 1. Extraoral photograph showing a blue-gray facial skin discoloration, affecting the upper and middle third of the face.



Fig. 2. Intraoral view showing a fibrous hyperplasia in the palate with a posterior pigmentation.

stains were also performed, and both were negative, excluding the possibility of melanin and hemosiderine pigments (Fig. 4 and 5). The palatal nodule was removed, and the microscopic examination confirmed the clinical hypothesis of fibrous hyperplasia. The pigmentation was observed inside the macrophages and scattered in the connective tissue. Perls stain was positive, being compatible with hemosiderine (Fig. 6). Finally, the patient was referred to her cardiologist with the diagnosis of facial skin pigmentation associated with amiodarone.

### Discussion

Amiodarone is an iodine-rich medication and one of the most effective and commonly used drugs available for treatment of cardiac arrhythmia.<sup>1-3,5</sup> It has a high lipophilicity and a long plasma half-life. Amiodarone prolongs the cardiac repolarization by the sodium and calcium channel block and nonselective  $\beta$ -adrenergic inhibition.<sup>5</sup> It has a variable (20%–80%) oral bioavailability and its hepatic metabolism results in mono-N-desethylamiodarone. The peak serum level of amiodarone, after oral dosage, is achieved within 3-7 hours.<sup>2</sup> Amiodarone exhibits several adverse effects, such as corneal deposition; phototoxicity and skin pigmentation; thyroid damage; and hepatic, gastrointestinal, myopathic, or neurological complications.<sup>3,4,6-8</sup> Drug interactions related to amiodarone also have been reported to cause diverse collateral effects.<sup>9</sup> The majority of these effects are related to the duration of the treatment and drug dosage. Intraorally, hypersalivation, blue pigmentation of the oral mucosa, and bitter taste have also been described.<sup>10</sup>

Adverse effects of the skin induced by amiodarone affect approximately 10% of patients, and is associated with a prolonged use of the drug (generally >1 year), a dosage of 200-800 mg daily, and/or sun exposure.<sup>3,4,6,7</sup> The mechanism by which it causes skin pigmentation is still controversial, but several theories have been considered, including drug-induced lipodosis, photosensitivity reaction to ultraviolet light, or leucocytoclastic vasculitis.<sup>11</sup> Harris et al compared the dosage and plasma concentration of amiodarone and its metabolites in patients with and without photosensitivity, and they did not

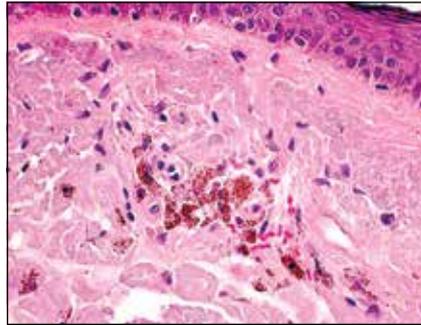


Fig. 3. Light microscopy photograph of the biopsy taken from the facial pigmented skin showing intracytoplasmic pigmented granules in macrophages mainly around the vessels and solar elastosis (H & E, 400X).

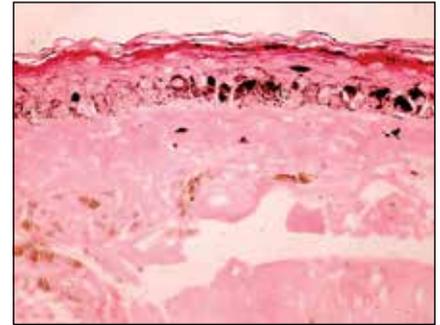


Fig. 4. Skin biopsy showing pigmentation in the connective tissue negative for Fontana-Masson stain. Note the internal positive control in melanocytes in the basal epithelial layer (400X).

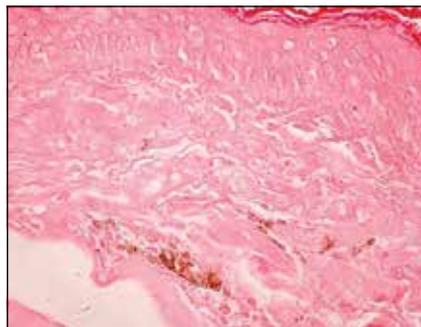


Fig. 5. Skin biopsy showing pigmented granules in the connective tissue negative for Perls stain (400X).

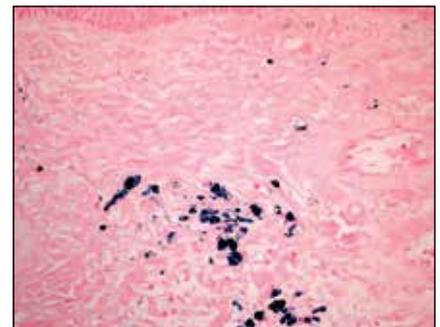


Fig. 6. Fibrous hyperplasia excisional biopsy showing positivity for Perls stain, compatible with hemosiderine (400X).

find any significant difference between the 2 groups.<sup>3</sup> There are 2 types of skin reactions associated with amiodarone. The first and most common is photosensitivity, which is characterized by pruritis and erythema; the second is a slate-grey discoloration of the sun-exposed skin, affecting only 1%-3% of patients, with a predilection for males.<sup>3,7,12</sup> The current case presents an asymptomatic facial pigmentation with a clinical appearance similar to other reports in the literature.<sup>4,12,13</sup> This pigmentation was not observed on other parts of the body. Facial skin pigmentation can be stigmatizing, since it may persist for long periods, even after amiodarone treatment is discontinued. However, there have been reports that the pigmentation can disappear within 2-24 months after withdrawal of the drug.<sup>4,12</sup> Corneal microdeposits, with no

impairment to visual acuity, also have been reported, but the patient in this case did not show any visual alterations.<sup>3,7</sup>

Skin biopsies typically show yellowish-brown or brown pigmented granules in macrophages of the dermis.<sup>7,13</sup> Studies have established that these granules contain iron, sulphur, iodine, amiodarone, and disethylamiodarone. Amiodarone and its metabolites bind to lipofuscin in macrophages, and tend to concentrate in areas of highly sun-exposed skin.<sup>3,7</sup> In addition, ultraviolet light induces amiodarone and its metabolites to bind to the blood vessel walls and the perivascular tissue, triggering an associated vasodilatation that increases the diffusion of these metabolites, resulting in chronic accumulation in the tissues.<sup>7</sup> The incisional skin biopsy of the current case showed similar histopathological features to the previous published cases.

The pigmentation of the oral fibrous hyperplasia was not associated with the skin pigmentation, and represented a reactive pigmentation due to deposits of hemosiderine in the dermis, probably caused by the chronic trauma on the palate with the upper denture.

Thyroid hormone alterations found in the patient can be explained since amiodarone inhibits the reversion of T<sub>4</sub> into T<sub>3</sub>, resulting in increased T<sub>4</sub> and TSH levels, and decreased T<sub>3</sub> levels, in long-term users. Our patient presented normal T<sub>3</sub> serum values, increased levels of T<sub>4</sub>, and decreased levels of TSH. The levels of aminotransferase were also altered (AST/TGO levels were increased and ALT/TGP levels were normal). Similar to complications reported in previous cases, these laboratory results indicate that the thyroid and hepatic function were altered due to the use of amiodarone.<sup>6,7,13</sup> Because of these adverse effects, it has been suggested that the dosage of amiodarone has to be determined individually, according to the results of the patient's follow-up.<sup>6</sup> The patient returned once after the diagnosis, with no improvement in thyroid hormones levels, because the medication was not discontinued by the cardiologist.

The association between amiodarone-induced skin pigmentation and multiple basal cell carcinomas has been reported.<sup>14,15</sup> The differential diagnoses include, but are not limited to, argyria, rosacea, and cutaneous lupus erythematosus. *Argyria* is manifested by a grey-bluish cutaneous pigmentation and is associated with

the intake of drugs or other substances containing silver. *Rosacea* is a chronic skin condition with predominantly facial manifestations, and is characterized by erythema, flushing, pustules, and telangiectasias. *Cutaneous lupus erythematosus* affects the face and other parts of the body and its diagnosis depends on a combination of clinical and laboratory findings.

## Conclusion

The detection of early signals of photosensitivity, thyroid dysfunction, or other alterations associated with the use of amiodarone must be checked closely by physicians, geriatrists, dermatologists, dentists, and other health professionals who may see patients that receive this drug, in order to prevent more severe complications.

## Author information

Dr. Gonzalez-Arriagada is a doctoral student, Oral Diagnosis Department, Semiology and Oral Pathology, Piracicaba Dental School, State University of Campinas (UNICAMP), Sao Paulo, Brazil, where Drs. Silva, Vargas, de Almeida, and Lopes are professors. Dr. Gonzalez-Arriagada is also a professor, Oral Diagnosis and Pathology, Facultad de Odontologia, Universidad de Valparaiso, Valparaiso, Chile.

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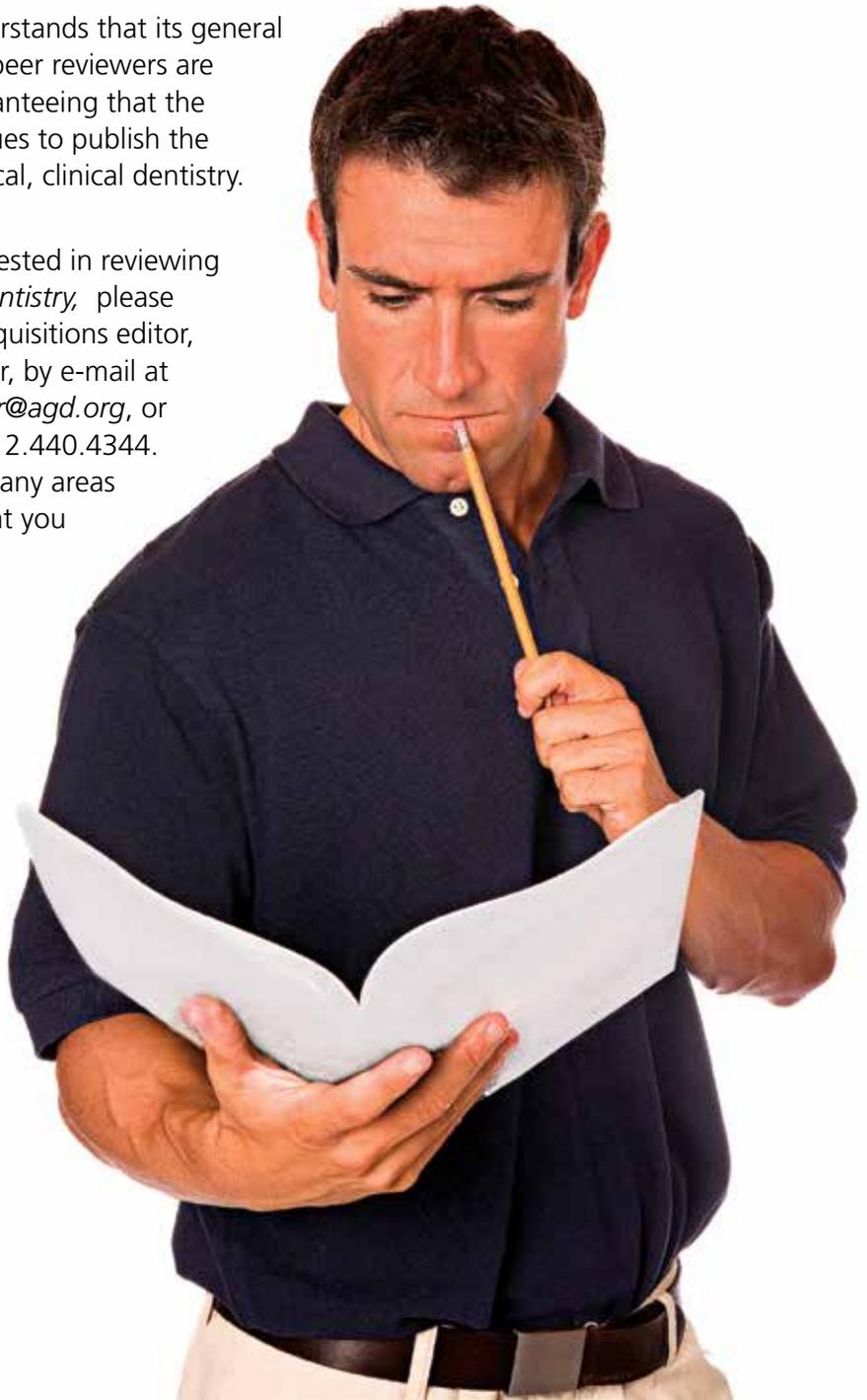
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