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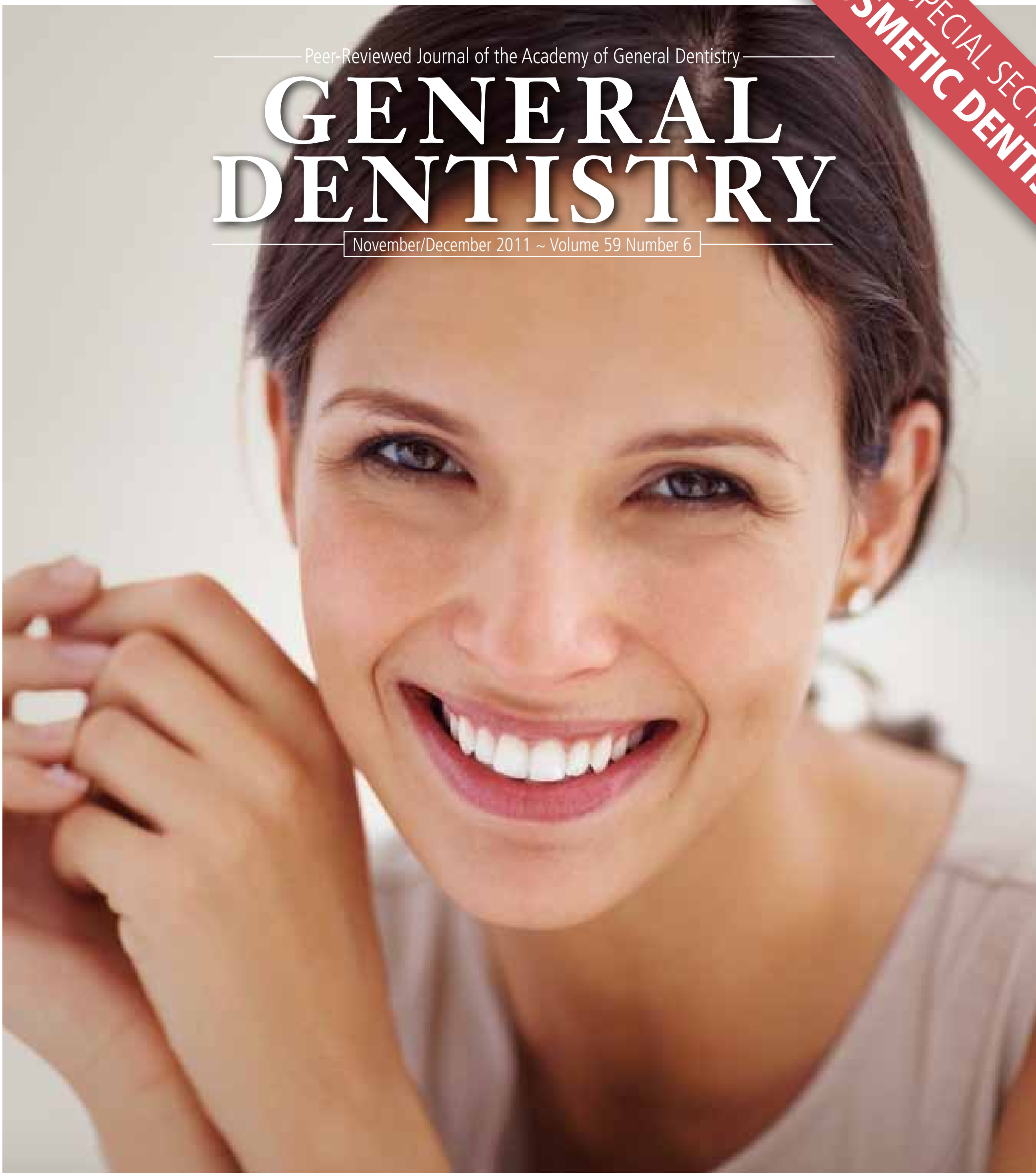

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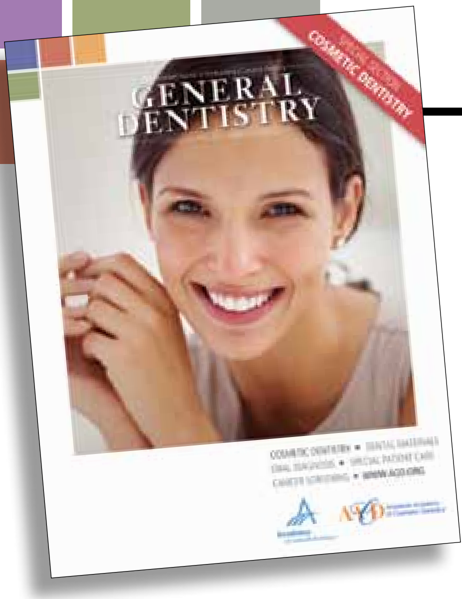

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Make no mistake(s)

If mistakes could be credited toward formal degrees, my walls would be filled with diplomas instead of animal mounts. Mistakes are part of the dues we pay for living a full life. Although they can be painful at times, a lifetime of mistakes indicates that we've lived life to the fullest and have accumulated a collection of valuable experiences. We cannot simply step into a world of unknowns and expect to make accurate, perfectly judged decisions. The legendary Alabama head football coach Paul "Bear" Bryant had a simple yet effective strategy for dealing with a mistake: Admit it, learn from it, and don't repeat it.

Of course, none of us want to admit that we make mistakes. But it happens to all of us, and if we're honest with ourselves and others, we can get a head start on repairing the damages. Admitting a mistake gives us the opportunity to correct it, while denying a mistake or trying to cover it up only makes the situation worse. History has taught us that nothing good comes from trying to cover up a mistake.

Our blunders and bloopers are a natural part of life and learning, and life is nothing if not a trial and error process. Sometimes, the best way to learn how to do something right is to do it the wrong way first. Eventually, though, we need to learn from our mistakes—we can't continue to do things the wrong way and conclude that they aren't working. Mistakes often expose our feelings, weaknesses, or lack of preparation, and the embarrassment that comes with making a mistake can make it difficult to step back, look at the situation objectively, and determine what we need to do differently the next time around. We must commit to being big enough to admit our mistakes, strong enough to correct them, and smart enough to learn from them.

Mistakes that occur at the dental office are a source of irritation, of course, but they can also be a golden opportunity to promote personal and professional growth. In addition to correcting mistakes on an individual level, it might be worthwhile to meet on a monthly or quarterly basis to review some of the mistakes that everyone has made—including the dentist. By discussing those mistakes, as well as what was learned from them, the entire staff can become more knowledgeable about how to handle situations that are bound to come up again. Learning from others' mistakes can save us time, frustration, and even money. Admitting to our mistakes opens us up to correcting them and moving forward; correcting our mistakes makes us all stronger in the long run.

Someone once said, "There is nothing wrong with making mistakes, just don't respond with encores." I've lost track of the number of times that I made a mistake, recognized how stupid it was, and then turned around and repeated the same mistake! Repeated blunders are the fruit of habit. We must break through the cycle of recurring mistakes, and we must create healthier habitual behavior that revolves around making the most of a situation. When you feel yourself beginning to enter the path of a familiar mistake, interrupt your journey and redirect your efforts.

"When you make a mistake, don't look back at it long. Take the reason of the thing into your mind, and then look forward. Mistakes are lessons of wisdom. The past cannot be changed. The future is yet in your power."
Hugh White, U.S. politician (1773–1840)

Roger D. Winland, DDS, MS, MAGD
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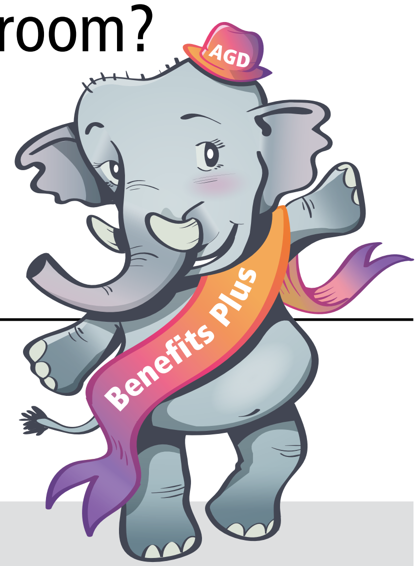

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Bevacizumab (Avastin): An anti-angiogenic drug associated with osteonecrosis of the jaw

Richard L. Wynn, PhD

Bevacizumab (Avastin, Genentech, Inc.) belongs to a class of drugs known as *anti-angiogenic agents* that are used with increasing frequency in treating cancer. Bevacizumab is indicated for the treatment of metastatic colorectal cancer and metastatic, nonsquamous, non-small cell lung cancer.

Angiogenesis in tumor cells involves the formation and growth of new blood vessels, which helps tumor growth. Bevacizumab acts to block angiogenesis through inhibition of cell proliferation and vessel sprouting, as well as by decreasing circulating vascular endothelial growth factor (VEGF) levels.[1] This action is similar to the anti-angiogenic action of the bisphosphonates.[1] Literature reports on patients receiving bevacizumab who developed osteonecrosis of the jaw (ONJ) are described below.

A case of ONJ associated with bevacizumab exposure was reported in a letter to the editor in 2008 by Greuter *et al.*[1] A 63-year-old woman was treated for breast cancer. Bone scans were normal, and the patient had never taken bisphosphonates. While being treated with liposomal doxorubicin and bevacizumab, the patient experienced left-sided maxillary pain after one month of therapy. A tooth infection was diagnosed and teeth No. 25 and 26 were extracted. One month later, a mouth-antrum fistula was surgically revised and occluded. Soon afterward, the patient suffered from a trigeminal neuralgia. Imaging showed maxillary sinusitis and signs of ONJ. The jaw lesion was extirpated and the sinus was drained. Histology verified the clinical diagnosis of ONJ, and an infiltration from the cancer was excluded. At a three-month follow-up, the patient remained free of lesions and symptoms.

The authors stated that this was the third published case of ONJ associated with bevacizumab therapy. The doxorubicin that the patient was taking is an anthracycline antineoplastic agent that has been on the market for many years and has never been known for causing ONJ. The authors suspected that bevacizumab, which hampers wound healing and possibly bone remodeling, was the causative agent in this case.

The other two published cases were included in a report by Estilo *et al.*[2]

A 51-year-old woman with a history of infiltrating ductal carcinoma of the right breast was diagnosed in late 2001 and treated with mastectomy in 2002. She subsequently underwent treatment with chemotherapy, doxorubicin, cyclophosphamide, and letrozole for various cycles over a three-year period. In 2006, she underwent additional chemotherapy, capecitabine therapy, and radiation. In late December 2006, she was started on bevacizumab at a dose of 15 mg/kg every three weeks for a total of eight doses, the last of which was given in May 2007.

Six weeks after receiving the last dose of bevacizumab, the patient presented with a two-month history of complaints of lower jaw discomfort and protruding bone in the lower jaw. Examination revealed an area of bone exposure in the left posterior lingual mandible, approximately 1 mm x 1 mm in diameter. The area appeared necrotic. The surrounding tissue showed no evidence of infection. The exposed bone was smoothed with a bone file and the patient was prescribed a 0.12% chlorhexidine oral rinse. The bevacizumab and capecitabine were discontinued. The area of exposed bone resolved within a few weeks, and the overlying mucosa appeared normal. However, at that time, a new area of exposed bone appeared, this time in the right posterior lingual mandible, measuring 1 mm x 1 mm in area. Histology showed devitalized necrotic bone with a scalloped "moth-eaten" appearance. Bacterial colonies occupied the demineralized areas.

The other case was a 33-year-old woman with a history of glioblastoma multiforme diagnosed in November 2006. She underwent surgery, followed by treatment with radiation therapy and temozolomide from December 2006 through January 2007. The patient started bevacizumab therapy in February 2007, receiving a dose of 10 mg/kg every two weeks. Thirteen weeks later, she was referred to the dental clinic for evaluation of a two-week history of spontaneous mucosal breakdown overlying her right mandible. The patient complained of gingival pain. On examination, a 1 cm x 2 cm dehiscence was noted at the junction of the unattached/attached gingiva in the mucobuccal fold overlying the mandibular right first and second premolars and first molars. Exposed necrotic bone was visible through the dehiscence, extending inferiorly and posteriorly. There was no evidence of infection. Otherwise, the oral mucosa appeared healthy, with intact dentition. The patient continued to receive bevacizumab biweekly. In August 2007, she returned with a small mucosal defect posterior to the original lesion. There was soft tissue dehiscence with no evidence of exposed bone.

The authors commented that the clinical features of bone exposure in the two cases were compatible with ONJ in patients exposed to bisphosphonate therapy, even though these two patients had no history of bisphosphonate use. The authors suggested that bevacizumab contributed to the oral mucosal breakdown with exposed necrotic mandibular bone. The anti-angiogenic property of bevacizumab could compromise microvessel integrity in the jaw and lead to subclinical compromise of the osteon. Trauma from toothbrushing or chewing also could increase the demand on this compromised bone to repair itself, resulting in localized bone necrosis, periosteal death, and eventual exposed necrotic bone.[2]

Estilo *et al* went on to explain that angiogenesis is a critical step in tumor growth, invasion, and metastasis.[2] VEGF is a family of cytokines that exert important functions in tumor angiogenesis. VEGF is overexpressed in various human tumors, and overexpression of VEGF is associated with tumor progression. VEGF is also essential for osteogenic differentiation and bone formation. Therefore, bevacizumab, used as a VEGF inhibitor to suppress tumor progression, could also suppress the osteogenic differentiation and bone formation. This could result in failure to repair bone trauma.

In the two patients described, some additional factors that might have contributed to the development of ONJ were the advanced cancer and chemotherapy. The authors cautioned that clinicians involved in the care of patients treated with bevacizumab should be aware of the potential complication of ONJ.[2]

Anti-angiogenic agents and the risk of ONJ

Christodoulou *et al* reported that a combination of bisphosphonates and anti-angiogenic factors induces ONJ more frequently than bisphosphonates alone.[3] Their introduction to the report stated that anti-angiogenic agents could add to the risk of ONJ, especially when used in combination with bisphosphonates. The purpose of their study was to do a retrospective review of data of patients receiving bisphosphonates with or without anti-angiogenic factors for osseous metastases from various tumors between June 2007 and June 2008.[3]

Among 116 patients being treated for various malignancies, 25 received concurrent treatment with anti-angiogenic agents at some point. Twenty-two were taking bevacizumab, two were taking a drug called *sunitinib,* and one was taking a drug called *sorafenib*. The median duration to exposure to bisphosphonates was 28.5 months for the 25 patients taking the anti-angiogenic drugs and 24 months for those not taking any anti-angiogenic drugs. There were no significant differences between the two groups regarding treatment duration with the bisphosphonate.

Of the 25 patients receiving concurrent treatment with bisphosphonates and the anti-angiogenic drug, four developed ONJ (16% incidence). Of the 91 patients receiving bisphosphonates without anti-angiogenic factors, only one developed ONJ (1.1% incidence). This difference was statistically significant.

In this study, the diagnosis of ONJ was made according to the clinical diagnoses made by dentists specializing in treating cancer patients and consisted of pain in the jaw with exposed, necrotic bone, some with purulent discharge. The authors commented that bisphosphonates have also been reported to possess anti-angiogenic acivity, particulary zoledronic acid (Zometa), a widely popular bisphosphonate used as an adjunct agent in cancer treatment.

Data from prospective clinical trials

Guarneri *et al* conducted a study to determine the incidence of ONJ in a large population of patients with locally recurrent or metastatic breast cancer treated with bevacizumab in prospective clinical trials, and to assess whether administration of bevacizumab (with or without bisphosphonate exposure) increases the risk of ONJ.[4] Data from three trials were reviewed. Trial one, known as *AVADO*, involved patients who were randomized to three weekly doses of docetaxel in combination with placebo or bevacizumab (7.5 or 15 mg/kg every three weeks).[5] Trial two, known as *RIBBON-1*, consisted of two independently powered cohorts, with chemotherapy selected by the investigator before randomization to either placebo or bevacizumab (15 mg/kg every three weeks).[6] The third study, known as *ATHENA*, was a large single-arm study with the primary objective of assessing the safety of bevacizumab in combination with standard first-line chemotherapy in the general oncology practice setting.[4] To determine the incidence of ONJ, each of the trial databases was searched for the terms "osteonecrosis" and "osteonecrosis of the jaw." The identified cases of ONJ were reviewed by medically qualified personnel. The incidence of ONJ was determined and statistical tests were used to compare the incidence of ONJ in patients receiving bevacizumab versus placebo and in patients with versus without bisphosphonate exposure.

Results

The incidence of ONJ in the population receiving bevacizumab with no bisphosphonate exposure in the first two trials was 0.2% (2/1,076); in bevacizumab with bisphosphonate exposure, it was 0.9% (2/233). Combining the results of the two trials, the overall incidence of ONJ among patients receiving bevacizumab-containing therapy in the first two trials with and without bisphosphonate exposure was 0.3% (4 of 1,309 cases). None of the 650 patients in the placebo groups experienced ONJ. Statistically, there was no difference between these two incidences (0.3% and 0%, respectively). In the third study (ATHENA), the overall incidence of ONJ in patients receiving bevacizumab-containing regimens was 0.4% (10 of 2,251 cases). All 10 of the reported cases in the ATHENA study were in patients treated with bisphosphonates. The 10 cases occurred in 425 patients taking bevacizumab with previous exposure to bisphosphonates. There were no cases of ONJ in the 1,826 patients taking bevacizumab with no exposure to bisphosphonates.

Summary

The incidence of ONJ in the population taking bevacizumab that had previous exposure to bisphosphonates was 0.9–2.4%. The incidence of ONJ in the population taking bevacizumab that had no previous exposure to bisphosphonates was 0.0–0.2%. The authors commented that the 0.9–2.4% incidence in patients exposed to bisphosphonates is within the 1–6% range reported for bisphosphonates alone in previous studies.[7,8]

In a published invited commentary on this study, Van Poznak said, "It is reassuring to see that bevacizumab does not appear to significantly increase the risk of ONJ in patients with locally recurrent or metastatic breast cancer treated with chemotherapy, with or without bisphosphonates."[9]

Dental management to reduce the risk of ONJ

According to Greuter *et al*, "If more cases of bevacizumab-associated ONJ are reported, special dental management (jaw x-ray, optimal dental health, and good oral hygiene) should become standard before patients start bevacizumab."[1]

The importance of special dental management to reduce the risk of ONJ in patients taking bevacizumab was shown in a recent report by Francini *et al*.[10] They looked at cancer patients on zoledronic acid and chemotherapy combined with bevacizumab who underwent a dental examination before starting treatment and found that none of the patients developed ONJ.

Their study included 59 patients with either breast cancer or non-small cell lung cancer who received 4 mg zoledronic acid IV every four weeks and 15 mg/kg bevacizumab every three weeks. The median time of receiving zoledronic acid was 18 months, and the median time of receiving bevacizumab was 16 months. All subjects received a dental examination and panoramic x-rays before starting treatment; this continued every three months until the patient died or was lost to follow-up. If needed, patients received periodontal disease treatment and underwent tooth extraction before they received any drug.

None of the patients required dentoalveolar surgery while undergoing cancer treatment. After a median follow-up period of 19.7 months, none of the participants developed ONJ. The conclusion was that a bisphosphonate combined with an anti-angiogenic drug did not predispose to ONJ in participants with cancer that metastasized to the bone who underwent a baseline dental examination and preventive dental measures.

Indications for bevacizumab (Avastin) approved by the FDA

The FDA-approved indication for the use of bevacizumab (Avastin) is as follows: "Treatment of metastatic colorectal cancer; treatment of unresectable, locally advanced, recurrent or metastatic nonsquamous, non-small cell lung cancer; treatment of metastatic HER-2 negative breast cancer (who have not received chemotherapy for metastatic disease); treatment of progressive glioblastoma; treatment of metastatic renal cell cancer (not an approved use in Canada).

"Note: For the treatment of metastatic breast cancer, effectiveness is based on improvement in progression-free survival; not indicated for the treatment of breast cancer with metastatic disease that has progressed following anthracycline and taxane treatment. For the treatment of glioblastoma, effectiveness is based on improvement in objective response rate."[11]

Unlabeled/investigational uses of bevacizumab

These uses include treatment of recurrent ovarian cancer, recurrent cervical cancer, soft tissue sarcomas (angiosarcoma or hemangiopericytoma/solitary fibrous tumor), and age-related macular degeneration (AMD).

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References

1. Greuter S, Schmid F, Ruhstaller T, Thuerlimann B. Bevacizumab-associated osteonecrosis of the jaw. Ann Oncol 2008;19(12):2091-2092.
2. Estilo CL, Fornier M, Farooki A, Carlson D, Bohle G 3rd, Huryn JM. Osteonecrosis of the jaw related to bevacizumab. J Clin Oncol 2008;26(24):4037-4038.
3. Christodoulou C, Pervena A, Klouvas G, Galani E, Falagas ME, Tsakalos G, Visvikis A, Nikolakopoulou A, Acholos V, Karapanagiotidis G, Batziou E, Skarlos DV. Combination of bisphosphonates and antiangiogenic factors induces osteonecrosis of the jaw more frequently than bisphosphonates alone. Oncology 2009;76(3):209-211. Epub 2009 Feb 12.
4. Guarneri V, Miles D, Robert N, Dieras V, Glaspy J, Smith I, Thomssen C, Biganzoli L, Taran T, Conte P. Bevacizumab and osteonecrosis of the jaw: Incidence and association with bisphosphonate therapy in three large prospective trials in advanced breast cancer. Breast Cancer Res Treat 2010;122(1):181-188.
5. Miles D, Chan A, Romieu G, Dirix LY, Cortes J, Pivot X, Tomczak P, Taran T, Harbeck N, Steger GG. Randomized, double-blind, placebo-controlled, phase III study of bevacizumab with docetaxel or docetaxel with placebo as first-line therapy for patients with locally recurrent or metatstatic breast cancer (mBC): AVADO. J Clin Oncol 2008;26(15S): (Abstract LBA1011).
6. Robert NJ, Dieras V, Glaspy J, Brufsky AM, Bondarenko I, Lipatov ON, Perez EA, Yardley DA, Chan SY, Zhou X, Phan SC, O'Shaughnessy J. RIBBON-1: Randomized, double-blind, placebo-controlled, phase III trial of chemotherapy with or without bevacizumab for first-line treatment of human epidermal growth factor receptor 2-negative locally recurrent or metatstatic breast cancer. J Clin Oncol 2011;29(10):1252-1260.
7. Hoff AO, Toth BB, Altundag K, Johnson MM, Warneke CL, Hu M, Nooka A, Sayegh G, Guarneri V, Desrouleaux K, Cui J, Adamus A, Gagel RF, Hortobagyi GN. Frequency and risk factors associated with osteonecrosis of the jaw in patients treated with intravenous bisphosphonates. J Bone Miner Res 2008; 23(6):826-836.
8. Bamias A, Kastritis E, Bamia C, Moulopoulos LA, Melakopoulos I, Bozas G, Koutsoukou V, Gika D, Anagnostopoulos A, Papadimitriou C, Terpos E, Dimopoulos MA. Osteonecrosis of the jaw in cancer patients after treatment with bisphosphonates: Incidence and risk factors. J Clin Oncol 2005;23(34):8580-8587.
9. Van Poznak C Osteonecrosis of the jaw and bevacizumab therapy. Breast Cancer Res Treat 2010;122(1):189-191.
10. Francini F, Pascucci A, Francini E, Miano ST, Bargagli G, Ruggiero G, Petriolli R. Osteonecrosis of the jaw in patients with cancer who received zoledronic acid and bevacizumab. J Am Dent Assoc 2011;142(5):506-513.
11. Drug information handbook for dentistry, ed. 16, 2010-2011. Wynn RL, Meiller TF, Crossley HC. Hudson, OH: LexiComp, Inc.;2011:232.

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Clinical tips for porcelain veneer cases with enamel hypocalcification

Bruce W. Small, DMD, MAGD

Bonded porcelain laminate veneers were introduced to dentistry in the early 1980s, although veneers were used as early as 1903.[1] Land's drawings in *Dental Cosmos* are not unlike the preparations we do today. The veneers of 100 years ago were cemented rather than bonded, but the idea of creating more esthetic smiles was much the same.

This column will review a completed case, highlighting a few common problems that occur when placing veneers and showing how they were resolved. Dealing with enamel hypocalcification, constructing provisional restorations, and isolation will be discussed.

Case report

A 17-year-old girl presented with two bonded direct composite resin restorations on teeth No. 8 and 9 (Fig. 1 and 2) and a chief complaint of enamel hypocalcification. A comprehensive examination was completed, including mounted diagnostic models, photographs, radiographs, periodontal charting, a TMJ examination, and clinical charting. The patient's father, a radiologist, wanted to limit treatment to a minimum but also wanted to improve the esthetics of his daughter's teeth.

During the consultation visit, at-home bleaching, crowns, and porcelain veneers were discussed and

Fig. 1. Preoperative view of the patient.

Fig. 2. Preoperative retracted view of maxillary anterior teeth.

Fig. 3. Shade check prior to bleaching.

Fig. 4. Preoperative view following bleaching for three weeks.

Fig. 5. Veneer preparations on teeth No. 8 and 9.

Fig. 6. Impression tray with OptraGate in place.

Fig. 7. Clear stent in place used for provisional restorations.

Fig. 8. Void in provisional being repaired with flowable composite.

Fig. 9. Flash of excess provisional material being removed with modified scaler.

Fig. 10. Completed provisional composite veneers.

explained in detail. Advantages and disadvantages of each procedure and previous case examples were shown. It was decided to attempt bleaching the patient's teeth, which in the author's experience has made enamel hypocalcifications less noticeable. Ten percent carbamide peroxide at-home bleaching was done three hours a day for three weeks, and the teeth lightened noticeably (Fig. 3 and 4). At this point, one option was to place veneers on four or six anterior teeth, but the patient decided to proceed with two porcelain veneers and leave the remaining teeth alone.

Preparation and impression

Conservative preparations were made on teeth No. 8 and 9 (Fig. 5), and impressions were taken following placement of retraction cord. An isolation device (OptraGate, Ivoclar Vivadent Inc.) was used to help with the cord packing, and an impression was taken using a polyvinyl siloxane material and stock tray (Fig. 6). This method of isolation allows the operator to visualize and access the operating field by keeping the lips and cheeks retracted.

Provisional restorations

The provisional restorations were made using a clear stent made from .020 coping material (Fig. 7). After the preparations were etched on the incisal edge only and a dentin bonding agent was placed on the entire facial surface and incisal edge, a bis-acryl material was placed on the inside of the stent and then placed over the teeth. When voids occurred, flowable composite was added, cured, and finished (Fig. 8). Excess flash of the provisional material can be removed by using an appropriate instrument such as an explorer or modified periodontal scaler or curette (Fig. 9). After complete curing, the material can be finished using carbides, diamonds, and sandpaper disks (Fig. 10).

Final restorations

The shade was chosen by concentrating primarily on the body shade of the adjacent lateral incisors with small maverick white stains. The veneers were seated and bonded in the usual manner, the margins were finished, and the occlusion was checked. The final result

Fig. 11. Anterior retracted view of completed final restorations.

Fig. 12. Lingual view of completed restorations.

Fig. 13. Close-up of patient's smile.

Fig. 14. View of patient with completed final restorations.

showed an adequate blend of shade without overdoing the white stains (Fig. 11–14)

Discussion

At times, anterior esthetic cases with grayish teeth and white enamel hypocalcifications can be very difficult to match shades when doing any dentistry. The case presented here shows that bleaching the teeth can minimize the difference between the white spots and the body shade of the other teeth. Combining this approach with an accurate shade selection and a competent laboratory will allow a chance for reasonable success.

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References

1. Land CH. Dental Cosmos 1903;45(8):615-620.

Manufacturers

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

Latest innovations in air and electric handpieces

Michael B. Miller, DDS

More than three years ago, this column featured an update on electric handpieces. Since that time, three significant innovations have occurred in the handpiece arena. The purpose of this column is to give clinicians previews of these innovations along with recommendations on which, if any, should be considered when purchasing decisions are made.

Air-powered handpieces

High-speed air turbine handpieces have ruled the North American market for many years, and, for the most part, they have performed satisfactorily, even though it is well-known that they lose torque when the bur hits the tooth. This power loss led to the emergence of electric handpieces, which are the standard in Europe and are beginning to take hold in other areas of the world.

But a new type of air-powered handpiece may change some minds when it comes to the superiority of electrics. The Midwest Stylus ATC (Dentsply Professional) looks and feels like the air-powered handpiece you might be using already, which means that its learning curve is essentially flat. Don't be fooled by appearances, though: The real advantage of the ATC over conventional air-powered handpieces is its coupler and control box. This is where the ATC (adaptive torque control) comes from.

As explained by the manufacturer, a sensor in the coupler tells the control box that you are about to cut through, for example, a nonprecious metal coping to remove a crown and that you need more power. The control box, which is referred to as an electronic "brain," increases the air pressure to give the handpiece the turbo boost necessary to cut through the hard metal. For light cutting tasks, the opposite effect is supposed to occur, that is, adequate torque at low speeds. In addition, the turbine has been redesigned to handle the higher air pressures.

Okay, this all sounds good, but does it perform as advertised? According to a recent evaluation by REALITY, the answer is yes, but with a significant qualifier. The REALITY evaluation confirmed that the 21 watts of power produced by the ATC doesn't falter when heavy pressure is applied, and while the handpiece doesn't possess the unbridled power of an electric, its performance was impressive nonetheless. What's more, all of this power is produced by a handpiece that weighs only 3.3 oz, which is average for air-powered versions.

So what is the significant qualifier? In a word, it is installation. Since the technology built into this handpiece is cutting-edge, the installation process is quite new for most technicians. At least three REALITY evaluators noted that the installation was anything but smooth, requiring several repeat visits to get it right. Even then, two evaluators continued to have problems with the handpiece.

Therefore, while the Midwest Stylus ATC is a terrific handpiece and earned five stars from REALITY, be absolutely certain that the technician installing it knows what he or she is doing. (I speak from personal experience on this as well. When my evaluation unit was installed, the technician was obviously struggling with it. I called Midwest directly and had their experts guide the technician. The result? The handpiece worked flawlessly.)

Electric handpieces

As noted previously, electric handpieces are the standard in Europe and are beginning to take hold in other areas of the world. Their tremendous and constant torque allows clinicians to cut teeth smoothly and reliably. However, electric handpieces have been significantly heavier and larger than their air-powered brethren, not to mention commanding a hefty premium price.

The COMFORTdrive 200 XDR (KaVo Dental) could be a game-changer for those who have been straddling the fence. The first thing you will notice is the handpiece itself: It looks like a conventional air-powered version, since the electric motor has been miniaturized and is built into its back end. This means that the handpiece is considerably smaller and lighter, weighing approximately 4.8 oz—still not in air-powered territory, but it is the lightest electric handpiece on the market that REALITY has tested.

On the other hand, smaller and lighter are not necessarily advantages if performance suffers. But don't worry—this is one powerful handpiece, with the motor stated to produce 30 watts of power. It also allows you to cut from 30,000–200,000 rpm. However, this speed regulation is not via the control box like it is for other electrics, where you can set a specific speed. This also means it can be used only as a high-speed handpiece, whereas other electrics, with interchangeable heads and angles, can be used at high and low speeds.

In other words, to get the small size and weight, you have to be willing to give up some of the benefits of the full-function electrics, including setting a specific speed. However, the simplicity of this model allows for an uncomplicated installation—simply connect it to a handpiece air line and you are ready to roll.

If you have held off looking for an electric handpiece because of size, weight, and complexity issues, you should at least add the COMFORTdrive to your shopping list.

Disposable handpieces

What happens if your favorite high-speed air turbine handpiece has a maintenance issue or is firmly ensconced in the autoclave when you really need it? You will probably grab for another handpiece that may or may not be in prime working condition. Another option would be to use a brand-new handpiece that comes in a sealed and sterile bag and never requires lubrication, cleaning, or autoclaving. That's because the handpiece is disposable—use it once and throw it away.

That's the idea behind the Azenic DHP (Azenic, Inc.). It is being marketed as fast, strong, lightweight, precise, ergonomic, and reliable, which are pretty heady claims for a plastic handpiece. I was amazed to discover that I agreed with nearly all of them…as long as you keep in mind that this instrument is, indeed, plastic and is meant to be disposable.

In the first place, the DHP looks like a conventional air-powered handpiece, and a pretty cool one at that, with a metallic silver-like ABS molded plastic cladding and a textured finish that keeps it from slipping in your hand even when it's wet. Its dimensions are within normal parameters, but you would be hard-pressed to find a handpiece weighing less than the 0.6 oz of the DHP. Contrast that with conventional handpieces that typically weigh about 3.3 oz, and you can appreciate why it feels feather-light in your hand.

The DHP attaches to your dental unit's tubing in one of two ways, either directly or with the optional adaptor module. When using the adaptor, you can take advantage of the fiber-optic rod running through the handpiece, as the adaptor has an onboard light source, which we measured at approximately 1,800 Lux. That amount of illumination is on the low end of what most handpieces produce, but it's adequate for a disposable handpiece. The adaptor looks like a conventional coupler, but you have to attach the handpiece through a screw-like attachment—there is no typical snap-on/snap-off like you get with a conventional coupler. The adaptor also adds approximately 1.1 in. (2.75 cm) to the length of the handpiece.

The one-port water spray is adequate and the fact that it has no chip air allows it to be used for surgical and root sectioning without the potential for causing an air embolism.

The procedures for inserting and changing burs are also a throwback to a simpler era before the advent of pushbutton chucks. With the DHP, you insert a bur into the chuck and then apply pressure by pushing the end of the bur against the small concavity on the back end of the violet plastic cap that you remove from the back of the handpiece before connecting it to your delivery system. To remove the bur, you are told to simply grab it with your fingers and pull it out or to insert the thin metal rod in the aforementioned cap in the hole in the back of the DHP and push the bur out. I found pulling the bur to be an exercise in futility, so pushing it out is definitely the method of choice.

I was impressed with the DHP's 20 watts of cutting power. It performs better than I expected, especially since it is being promoted as a complement, not a replacement, for conventional handpieces. On the other hand, make sure you don your earplugs—the REALITY noise test found that the DHP produced 92.6 dBA, which is approximately 20 dBA higher than most conventional handpieces.

At $23 each, the cost of these disposable handpieces could add up pretty quickly, so using them judiciously would be a wise move. Nevertheless, for those times when you need a reliable backup or when you perform outreach services, the DHP could be one less item to worry about.

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Manufacturers

Azenic, Inc., Kalamazoo, MI
888.347.7576, azenic.com

Dentsply Professional, Des Plaines, IL
800.989.8825, www.stylusatc.com

KaVo Dental, Charlotte, NC
888.275.5286, www.kavousa.com

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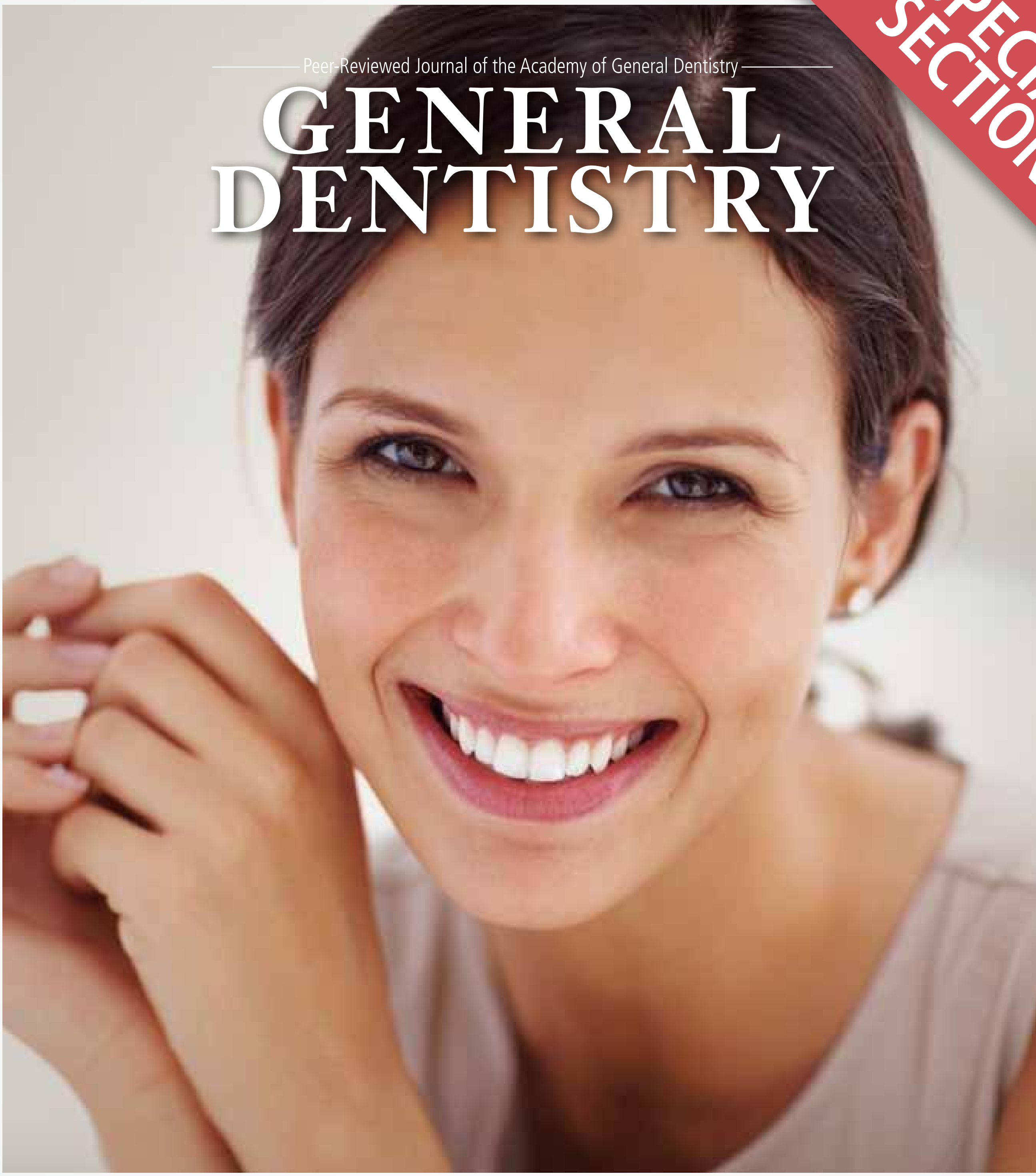

COSMETIC DENTISTRY

The Academy of General Dentistry (AGD) and the American Academy of Cosmetic Dentistry (AACD) bring you this special section on cosmetic dentistry

Academy of General Dentistry™

American Academy of Cosmetic Dentistry®

AACD: More relevant than ever

To paraphrase author Susan Sontag, "Existence is no more than the precarious attainment of relevance in an intensely mobile amalgam of past, present, and future."

Having recently assumed the position of President of the American Academy of Cosmetic Dentistry (AACD), relevance—and existence, for that matter—is on my mind. Remaining relevant is the key to growth, satisfaction, and delivering professional achievement, especially as it relates to the associations that serve dentistry.

That's exactly why I'm so energized about the AACD's trajectory. I'm encouraged by statements from new AACD members like this one, who, when asked why she joined the AACD, said, "I have been practicing cosmetic dentistry for more than 30 years. I would like to be affiliated with a world-renowned organization that reflects my beliefs in professionalism, excellence, and education."

And this one: "I own a very progressive high-tech laboratory, and I am looking to advance the skills of my technical team and also stay up to date with the ways in which we can better serve our current and future patients."

Finally, I was especially gratified to hear this from a recent dental school graduate: "After attending my first AACD conference, my eyes were opened to a whole new world of dentistry whose surface is barely scratched while in school. I was intrigued by the level of work that was on display by this year's Accredited members and realized that this is certainly the level of care that I wish to achieve some day."

Even so, we have to ask ourselves, how can we continue to build on the best of the past—learning from the legacy and examples of former leaders—while constantly evolving to stay relevant and meaningful to the next generation of cosmetic dentists and laboratory technicians?

The relevance of open doors

The American Board of Cosmetic Dentistry® (ABCD), the credentialing authority of the AACD, recently opened Accreditation to any dentist or laboratory technician willing to accept the challenge to pursue the highest standards, thus underscoring the AACD's dedication to inclusiveness and standards of excellence. This decision represented a visionary and historic change for the AACD and was arrived at only after long and careful deliberation.

The concept of Accreditation is unique in that success is solely dependent upon demonstration of knowledge and excellence in cosmetic dentistry in a three-step system: a written examination, a clinical case examination, and an oral examination.

By opening the door for non-members of the AACD to pursue Accreditation, the ABCD acknowledges and promotes Accreditation as a significant achievement—not only within the confines of the AACD but within the scope of the dental profession. In addition, the ABCD believes that the credential is unbiased—competency and quality are judged independent of alignment with a particular organization—and obtainable for all those willing to meet the standard. It's a service to the public, not merely a self-serving benefit of membership.

The relevance of continuing education

The AACD's "brand" of continuing dental education is based on a foundation of experiential, hands-on, and collaborative learning. For instance, the AACD's Annual Scientific Session brings together dentists, lab techs, and team members in an environment that fosters more efficient communications. In addition to the Annual Scientific Session, we're busy adding regional and international programming to reach dental professionals where they live. Our peer-reviewed clinical journal, the *Journal of Cosmetic Dentistry,* now features a fresh, contemporary design, tests for earning CE credits, and a credible editorial review board, making it an even more frequently referenced publication.

The relevance of giving back

The AACD Charitable Foundation's Give Back a Smile program helps to rebuild the lives and dignity of survivors of domestic violence through compassionate cosmetic dental services. Our program volunteers not only restore smiles, they are privileged to restore lives. And giving back helps to differentiate them in their communities by standing for something noble and meaningful.

The relevance of listening to our members

We continue to ask our members what they want from the AACD, and we've used that input to prioritize our activities and our offerings. We recently introduced a robust e-learning program to our benefits portfolio, and we're leveraging technology to help our members grow their practices. We've improved our website and its searchability so that more prospective patients can locate an AACD dentist near them. In addition, we now offer smartphone and iPad apps for our Annual Scientific Session and digital readers for the *Journal of Cosmetic Dentistry.* And "My AACD" online communities put the power of social networking in the hands of our members, helping them connect with, support, and encourage one another.

Is the AACD relevant to the world of general dentistry? I believe it is, but that's a question you'll have to answer for yourself. In closing, I wanted to share this response from a new member, who, when asked why he joined the AACD, simply stated, "It's about time, don't you think?"

John K. Sullivan, DDS, AAACD
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Finishing and polishing criteria for minimally invasive composite restorations

Brian LeSage, DDS, FAGD, FAACD

To achieve the benefits that composite restorations can provide, it is incumbent on dentists to understand the importance of proper finishing and polishing techniques and how to incorporate them appropriately into everyday practice. A smooth surface finish is clinically necessary because the presence of surface irregularities from poor finishing and polishing can lead to staining, plaque retention, gingival irritation, recurrent caries, abrasiveness, wear kinetics, and tactile perception by the patient. However, finishing and polishing procedures for direct composite restorations are technique- and material-sensitive. This article describes the proper composite material placement considerations, as well as finishing and polishing techniques and materials, for providing highly esthetic, long-lasting restorations. By incorporating such protocol into their everyday practices, dentists can increase the long-term esthetic and plaque-resistant predictability of direct composite restorations.

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Compared to earlier generations of direct restorative materials, today's composite resins provide improved strength, resistance to wear, and esthetics, and have revolutionized the concept of minimally invasive dental treatment.[1] One of the most versatile materials, composites can be used for direct restorations, build-ups, cementation, diagnostic mock-ups, gingival stabilization, provisionals, and prototypes.[2] Composites are available in many forms, including hybrid, microfill, and nanofilled/nanohybrid formulations, and the materials have evolved, with the science behind them solving many of the problems experienced with materials of the past.[1]

Earlier generations of composite materials presented challenges, such as polymerization shrinkage and the potential for marginal leakage resulting in the development of secondary caries.[3] The benefits of newer formulations also eliminate many problems associated with amalgam.[4,5] Historically, amalgams could result in cusp fractures, increased rates of secondary caries, and potential toxicity from mercury.[4,5] Using composites for direct restorations helps to minimize some of these risks and eliminates those associated with mercury in amalgam.[4,5]

Further, the newer composite formulations demonstrate high polishability for maintenance over the life of the restoration. In addition to contributing to esthetic value and appearance, optimal surface polishability has been proven to reduce staining and plaque accumulation while minimizing wear.[3,6] Studies have shown that improper finishing and polishing can lead to gingival irritation, recurrent caries, abrasiveness, and tactile perception.[6,7] Therefore, to obtain the added benefits that composite restorations can provide, clinicians must understand the importance of proper finishing and polishing techniques and how to incorporate them into everyday practice.

Finishing and polishing composites

By definition, *finishing* is gross contouring or reduction to obtain the required anatomy for a restoration, while *polishing* refers to the reduction in roughness and scratches typically created by finishing instruments.[6,7] Properly finishing and polishing composite restorations offers many benefits that ultimately lead to a predictable, long-lasting, and highly esthetic result.[6,7] Regardless of the cavity class or location, a smooth surface finish is clinically necessary because the presence of surface irregularities from poor finishing and polishing can lead to staining, plaque retention, gingival irritation, recurrent caries, abrasiveness, wear kinetics, and tactile perception by the patient.[6,7]

For example, in the oral environment, bacterial survival depends on the ability of bacteria to attach to hard surfaces like teeth, filling materials, dental implants, and prostheses.[8] Clinical studies have demonstrated that surface roughness greatly impacts the initial adhesion and retention of microorganisms on hard surfaces; surfaces that are rougher typically retain more plaque than those that are smoother.[8] Additionally, it has been suggested that the threshold surface roughness where no further reduction in bacterial accumulation can be obtained is 0.2 µ.[9] However, surface roughness above this threshold has been correlated with an increase in plaque retention, as well as the incidence of secondary caries, gingival irritation, and loss of esthetics due to discoloration.[8,9] In cases of patients with poor oral hygiene, these issues often are exacerbated and can lead to the onset of subclinical or clinical gingival inflammation.[8]

Proper finishing and polishing also reduces the incidence of wear and marginal breakdown as well as preventing the buildup and retention of plaque and promoting the oral health of the soft tissues surrounding the restorations.[9,10] Studies have shown that unpolished restorations demonstrate increased incidences of friction and, therefore, increased wear of opposing enamel on occlusal contact areas.[11,12] Contributing to this wear, improper finishing and polishing could cause topographical changes and can introduce subsurface microfractures in the composite.[13-15] For example, when finishing composite restorations, carbide-laminated burs and regular grit diamonds do not produce the marginal integrity that fine, extra-fine, and ultra-fine finishing diamonds do; coarse diamonds can remove excess composite material and could result in composite surface crazing or cracking.[14,16]

The manner in which direct restorations are finished and polished also affects patient comfort.[6] An improperly finished and polished surface remains rough and negatively affects the patient's tactile perception of a restoration.[6] Research has shown that a change in surface roughness of only 0.3 µm can be detected by the patient with the tip of the tongue.[6] Therefore, to ensure patient comfort with the restoration, the surface should be smooth and feel as natural as the surrounding dentition.[6]

Overall, proper finishing and polishing allows clinicians to achieve proper marginal adaptation of the restorations and maintain natural surface luster and contours necessary to mimic the surrounding dentition.[13] However, finishing and polishing procedures are technique- and material-sensitive. Just as classes of composite materials demonstrate different esthetic qualities and tensile strengths, polishability and maintainability in the long-term can vary, based on inherent particles and filler size.[7,17]

Research has demonstrated that composite filler size and the systems used to finish and polish restorations influence surface roughness and staining. Study results indicate that composites polished with finishing systems from the same manufacturer exhibit less surface roughness and staining.[17] Hybrid composite resins—which contain matrix and filler particles of varying hardness, as well as a combination of large and small particles—achieve a smooth, flat surface when finished with 12- or 30-fluted carbide burs.[18,19] Using diamond burs could lead to crazing, composite loss, and surface irregularities that can affect a restoration's wear resistance.[16,18] Polishing hybrid composite restorations is best accomplished with aluminum oxide polishing pastes.[18] Microhybrid composites achieve the smoothest surface when polished with silicone polishing systems.[7]

Microfill composites can suffer fractures and other damage when finished with carbide burs. Microfilled composites are more appropriately finished with wet finishing diamonds.[18] Restorations created with these composites are ideally polished with 1 µm grit aluminum oxide polishing pastes.[18]

The literature indicates that nanofilled composites have been successfully polished using respective combinations consisting of 40 µm diamonds, 42 µm silicon carbide polishers, 6 µm silicon carbide polishers, and polishing paste.[20] Additional research suggests that diamond polishing points, diamond paste, and urethane-backed aluminum oxide disks also produce clinically acceptable levels of smoothness during the polishing process.[21]

Composites

Adhesively bonded composite restorations demonstrate esthetically acceptable results that conserve sound tooth structure and offer the potential for tooth reinforcement. The least invasive and most predictable restoration of teeth to normal form and function, tooth-colored composites provide patients and dentists with cost-effective and long-lasting solutions for a variety of indications. There are, however, certain criteria that composites must meet.

In general, composites should mirror natural tooth structure in color and translucency, withstand function in high stress-bearing areas over time, have seamless or undetectable margins, and allow for a polish that can be maintained over the life of the restoration. Now available in a variety of formulations for different indications, today's composites provide many added benefits, specifically in finishing and polishing, compared to the conventional materials of the past. For example, hybrid or microhybrid composites—universally referred to as *microhybrids*—are heavy-loaded materials that demonstrate high strength and opacity similar to that of natural dentin and enamel.[22,23] Additionally, microhybrids are less likely to chip or fracture because they

Fig. 1. Slightly underexposed before showing the depth of color, chroma, and translucency.

Fig. 2. Putty matrix trimmed to the facial incisal line angle, shown here on tooth No. 8 using a customized typodont.

Fig. 3. Putty matrix with first increment of the 3-D characterized build-up showing lingual enamel increment. (Note that the preparation to the free gingival margin and removal of the incisal edge in this case was performed for teaching purposes only. Rarely would teeth need to be prepared this aggressively.)

demonstrate excellent strength and the ability to withstand functional stresses.[22,23] Microhybrids blend with the natural dentition to create an esthetic restoration, allowing the practitioner to mimic dentin and enamel morphology.[22,23]

An issue with this class of composite materials, however, is their inability to maintain a polish; they tend to lose surface gloss over time and are less stain-resistant than other generations of composite.[17,22-24] Filler particles in microhybrids have been shown to "pluck out" during the polishing process and normal lifespan in the oral cavity, and, as a result, restorations can lose gloss or luster over time.[24] Studies have demonstrated that although it might not be as easy to maintain a polish as it is for other classes of composites, hybrids tend to be resistant to surface microfractures during finishing, for reasons that are believed to be directly related to the presence of inorganic fillers and their ability to absorb energy.[17,25]

In comparison, microfill composites demonstrate high polishability that lasts for the long term.[22,23] Many authors have gone so far as to deem the smoothness achieved with microfill composite materials as "permanent."[25] A direct effect of the inclusion of colloidal silica particles in the polymer matrix, small fillers and a resin-rich surface promote an excellent and maintainable polish.[26] Additionally, microfills demonstrate a higher resistance to wear and abrasion and a translucency that is similar to that of natural enamel.[22,23] This class of composites lacks the strength required in functional areas and often translucency is too great.[22,23] Despite its high polishability, this class of composites demonstrates a higher susceptibility to stain than newer generations of composite.[17]

The newest class of composite materials, nanofills have the *potential* to maintain greater strength, long-term polishability, and stain resistance.[17,27,28] Studies have illustrated that nanofilled materials exhibit the lowest incidences of roughness and wear after finishing and polishing and on recall when compared to other classes of dental composites.[29] This class of composites demonstrates the smoothest polished surface and lowest surface roughness, regardless of the polishing system used.[7] Additionally, with a greater resistance to wear, nanofilled materials offer the most ideal mechanical and optical properties.[27,28] Further, nanofilled composites display opacity similar to that of natural enamel and dentin, with translucency similar to that of enamel.[27,28] Demonstrating high strength, nanofilled composites also are less likely to chip in high-stress areas.[27,28] The only true disadvantage to nanofilled composites is the lack of *in vivo* long-term studies, because the material science is relatively new.[27-29]

Composite placement considerations to enhance the finishing and polishing processes

Using a typodont with denture teeth (Premium teeth, Heraeus Kulzer, Inc.), the following protocol demonstrates proper material placement considerations and finishing and polishing techniques and materials for providing highly esthetic, long-lasting restorations for teeth No. 7 and 8 (Fig. 1). By incorporating such protocol into everyday practice, dentists can increase the long-term esthetic and plaque-resistant predictability of direct composite restorations.

After developing a proper treatment plan, including identification of patients for whom composite restorations would be contraindicated (for example, those who have occlusal issues or bite

Fig. 4. Completed 3-D layer achieved to full contour using Bisco Aelite composite system (All-Purpose Body & Aelite Enamel Esthetic).

Fig. 5. Articulating paper aids with and confirms correct outline form, line angles, and axial inclination when establishing primary and secondary anatomy.

Fig. 6. Using the detailed finishing and polishing sequence results in the correct color, translucency, luster, and polish.

Fig. 7. Before image of tooth No. 7 demonstrating the starburst bevel in the rare instance where preparation might be required to allow for an undetectable restoration.

their fingernails), selection of the proper composite class, and evaluation of the patient's existing dentition, utilize the proper tools and protocols to ensure the best results. This involves taking steps during the placement process that will lead to the least amount of adjustment to the restoration once the composite has been built up. For example, polyvinyl siloxane matrixes provide placement limits in terms of volume of composite material three-dimensionally and can be used as adjuncts to help maintain the proper incisal length and edge thickness (Fig. 2 and 3).[30,31] By doing so, finishing and polishing will be predictable and much simpler (Fig. 4–6).

Reduction guides

When creating direct resin restorations, preparation is of the utmost importance (Fig. 7). Overly aggressive preparation for the sake of esthetics often leads to unnecessary loss of tooth structure.[32] Although necessary in some extreme cases, this loss of tooth structure typically can be avoided with the use of a reduction guide.[32] Further, reduction guides have proven useful in controlling midlines in cases requiring diastema closure and when complex bonding is required.[32]

Proper handling

Whether the composite material is placed on the facial surface, interproximally, or around the gingival tissues, the manner in which the composite is handled can greatly affect the appearance of a restoration. To handle composites properly, ensure that no air voids are present in the increments being placed. Further, placing smaller increments predictably, instead of placing bulk quantities of material at once, helps to ensure proper control of the material. Sensitivity can be eliminated by completely curing each composite increment and allowing the restorations to reach their full photocure potential.

Undetectable margins

To create undetectable margins in the esthetic zone that are not only esthetic but also resistant to leakage, a starburst bevel should be used, followed by etching beyond the bevel.[32-35] The outer layer of composite must be rolled while wearing clean gloves to improve sculptability and prevent voids. The material should then be placed, supercured, and allowed to "relax" for at least five minutes to allow the material to settle.[33-35]

Next, the margin should be addressed and finished back between where the etch-and-bevel ends. To ensure the best results, rubber wheels and polishers should not be used on the margins, because the rubber tends to become easily embedded in this area.[13,35,36]

Finishing and polishing technique considerations

Once the composite has been placed, a proper finishing and polishing protocol ensures a quality restoration. By understanding the following caveats of composite finishing and polishing, a predictable and long-lasting result can be achieved without concern for recurrent issues and further removal of healthy tooth structure.[37]

Gross contour (anterior restorations)

To properly finish composite after successful layering and 3-D anatomical construction (using an

Fig. 8. A red-stripped, flame-shaped, fine diamond is used to establish outline form and facial planes.

Fig. 9. A yellow-stripped, flame-shaped, extra-fine diamond further develops the proper contours.

Fig. 10. A green-stripped, coarse diamond is used with very light pressure and an electric handpiece to place texture in a prepolished direct composite restoration.

Fig. 11. A coarse disc (Bisco Composite Disc System) is used to establish transition line angles and incisal edge planes.

Fig. 12. A medium disc is used to initiate finishing protocol.

incisal putty matrix), the restoration should be evaluated for similar harmony and balanced width and length across the central incisors, as well as to balance with the laterals and canines. The flap door facial matrix often proves useful in ensuring that a proper facial contour has been achieved.

Removal of excess materials and recontouring is performed first. To that end, a variety of finishing devices have been proposed, including coated abrasive disks, carbide burs and stones, fine diamond burs, and resin- or silicone-impregnated burs.[7,14]

Gross contours can be established using a red-stripped diamond (8863-012, UCLA Anterior Aesthetic Restorative Kit, Brasseler USA), coarse discs, and a yellow-stripped diamond (863EF-012) (Fig. 8 and 9). Note that research indicates the lowest incidence of defective margins occurs when all three types of finishing diamonds (fine, extra-fine, and ultra-fine) are used.[14]

Texture and anatomy

Texture must be imparted on the restoration and the tertiary anatomy must be fine-tuned to impart realism. Texture can be placed using a multitude of armamentarium, including gross coarse diamonds (for example, No. 6856L-020, UCLA Anterior Aesthetic Restorative Kit) (Fig. 10), No. 557 cross-cut burs, and rubber points and wheels used both vertically and horizontally, preferably and most easily with electric handpieces (for example, NSK electric handpieces, Brasseler USA).

Again, to simplify this process, the matrix should be used and the composite should be layered carefully to ensure accurate and precise placement.[1] At this stage, the line angles will become more well-defined and the clinician should have a logical, sequential, and predictable method of finishing and polishing which ultimately will lead to a restoration surface that will accept and reflect light.[12] Further, the surface should not display voids, defects, stains, or pits.

Prior to finalizing and mirroring the natural dentition in luster, coarse and medium discs are used which, in many cases, will lessen any of the initial texture placed in the restoration (Fig. 11 and 12). A well-polished material can be the outcome, so the texture can be reapplied to play into realism.

Polishing

Achieving the appropriate luster and polish on a composite restoration is crucial because it contributes to factors other than esthetics. A proper polish that lasts for the long term reduces the adhesion of bacteria and plaque to the restoration and prevents marginal leakage.

Additionally, when polished correctly, composite restorations demonstrate improved resistance to staining. The life of the restoration also will be extended by eliminating the need for early removal purely for esthetic purposes.

To complete polishing of esthetic direct composite restorations, a system from the same manufacturer that incorporates polishing paste, points, cups, and wheels and silicone brushes is recommended.[17] The use of assorted polishing instruments has been shown to produce variations in surface roughness after polishing.[7] To obtain the final luster and polish, a goat-hair chamois brush (Brasseler USA) or a regular chamois brush with polish paste should be used. When using goat-hair chamois brushes, they should be wet and well-coated with polishing paste (Enamelize, Cosmedent, Inc.) with firm pressure initially, then used dry with adequate polishing paste at high speed to complete restoration polishing (Fig. 13). Again, run the brush vertically and horizontally. During this process, fine or medium discs again might be needed, after which the goat-hair brush is used to finalize the polishing protocol (Fig. 14).

Verify occlusion

The final step in any direct composite restoration, occlusion should be verified one last time after finishing and polishing.

Fig. 13. A goat-hair brush with composite polishing paste is used to achieve appropriate luster.

Fig. 14. 3-D characterized composite, mirroring and emulating the denture tooth (Heraeus Kulzer, Inc.) in contour, color, and luster.

Fig. 15. Preoperative view showing the patient's diastema.

Fig. 16. Retracted preoperative view showing the diastema and incisal edge wear.

Fig. 17. Close-up view showing maverick coloring and polychromicity built into the restoration using the nanohybrid composite.

Fig. 18. View of the restorations the day after completion, showing an improved esthetic result.

Case report

A 29-year-old woman came to the clinic unhappy with the space between teeth No. 8 and 9 (Fig. 15 and 16). With no removal of tooth structure and only an additive direct technique, composite restorations were placed to close the diastema (Fig. 17). Using a matrix, a nanohybrid universal composite (Venus Diamond, Heraeus Kulzer, Inc.) was placed according to a 3-D characterization layering technique and the finishing and polishing protocol described in detail above was followed. The final restorations mirrored each other and the surrounding dentition enhanced the patient's smile (Fig. 18).

Summary

In the case described above, the clinician was able to restore function and esthetics by following placement and finishing and polishing protocols noted here. By doing so, the risk for recurrent issues such as secondary caries, gingival inflammation, staining, plaque buildup, and marginal leakage, among other factors, was greatly reduced. Further, by precisely planning the case prior to completing any preparation or placement, the clinician was ensured a more predictable, esthetic, and much simpler restorative solution. When addressing a case such as the one presented here, remember the keys to success—observation, strategic control, careful selection, and manipulation of the desired material during placement, finishing, and polishing—for achieving a long-lasting and desirable composite restoration.

By adhering to the requirements of the specific composite and restoration, the ideal contour, finishing, polish, and luster were achieved in the restorative result. Incorporating an appropriate polishing sequence and system based on the materials used can enable dentists to provide patients with composite restorations that demonstrate predictable long-term esthetics, plaque and stain resistance, and function.

Author information

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References

1. Morgan M. Finishing and polishing of direct posterior resin restorations. Pract Proced Aesthet Dent 2004;16(3):211-217.
2. Trushkowsky R. Versatility of resin composite: Esthetic considerations. Compend Contin Educ Dent 2001;22(4):352-358.
3. Ritter AV. Direct resin-based composites: Current recommendations for optimal clinical results. Compend Contin Educ Dent 2005;26(7):481-490.
4. Mackert JR Jr, Wahl MJ. Are there acceptable alternatives to amalgam? J Calif Dent Assoc 2004;32(7):601-610.
5. Wahl MJ. A resin alternative for posterior teeth: Questions and answers on dental amalgam. Dent Update 2003;30(5):256-262.
6. Bashetty K, Joshi S. The effect of one-step and multi-step polishing systems on surface texture of two different resin composites. J Conserv Dent 2010;13(1):34-38.
7. Senawongse P, Pongprueksa P. Surface roughness of nanofill and nanohybrid resin composites after polishing and brushing. J Esthet Restor Dent 2007;19(5):265-275.
8. Giacomelli L, Derchi G, Frustaci A, Bruno O, Covani U, Barone A, De Santis D, Chiappelli F. Surface roughness of commercial composites after different polishing protocols: An analysis with atomic force microscopy. Open Dent J 2010;15:191-194.
9. Jefferies SR. Abrasive finishing and polishing in restorative dentistry: A state-of-the-art review. Dent Clin North Am 2007;51(2):379-397.
10. Ferreira Rde S, Lopes GC, Baratieri LN. Direct posterior resin composite restorations: Considerations on finishing/polishing. Clinical procedures. Quintessence Int 2004;35(5):359-366.
11. Krejci I, Lutz F, Boretti R. Resin composite polishing—Filling the gaps. Quintessence Int 1999;30(7):490-495.
12. Watanabe T, Miyazaki M, Takamizawa T, Kurokawa H, Rikuta A, Ando S. Influence of polishing duration on surface roughness of resin composites. J Oral Sci 2005;47(1):21-25.
13. Peyton JH. Finishing and polishing techniques: Direct composite resin restorations. Pract Proced Aesthet Dent 2004;16(4):293-298.
14. Maresca C, Pimenta LAF, Heymann HO, Ziemiecki TL, Ritter AV. Effect of finishing instrumentation on the marginal integrity of resin-based composite restorations. J Esthet Restor Dent 2010;22(2):104-113.
15. Schmidlin PR, Gohring TN. Finishing tooth-colored restorations *in vitro:* An index of surface alteration and finish-line destruction. Oper Dent 2004;29(1):80-86.
16. Leinfelder K. Commentary. Effect of finishing instrumentation on the marginal integrity of resin-based composite restorations. J Esthet Restor Dent 2010;22(2):113.
17. Berger SB, Palialol ARM, Cavalli V, Giannini M. Surface roughness and staining susceptibility of composite resins after finishing and polishing. J Esthet Restor Dent 2011;23(1):34-45.
18. Terry DA. Finishing and polishing adhesive restorations: Part II. Pract Proced Aesthet Dent 2005;17(8):545-548.
19. Boghosian AA, Randolph RG, Jekkais VJ. Rotary instrument finishing of microfilled and small-particle hybrid composite resins. J Am Dent Assoc 1987;115(2):299-301.
20. Zimmerli B, Lussi A, Flury S. Operator variability using different polishing methods and surface geometry of a nanohybrid composite. Oper Dent 2011;36(1):52-59. Epub 2011 Mar 24.
21. Endo T, Finger WJ, Kanehira M, Utterodt A, Komatsu M. Surface texture and roughness of polished nanofill and nanohybrid resin composites. Dent Mater 2010;29(2):213-223.
22. Hervas-Garcia A, Martinez-Lozano MA, Cabanes-Vila J, Barjau-Escribano A, Fos-Galve P. Composite resin. A review of the materials and clinical indications. Med Oral Pathol Oral Cir Bucal 2006;11(2):E215-E220.
23. Lutz F, Setcos JC, Phillips RW, Roulet JF. Dental restorative resins. Types and characteristics. Dent Clin North Am 1983;27(4):697-712.
24. Can-Karabulut DC, Ozyurt P, Gurbuz A, Gullu A. Usage of fiber-reinforced resin instruments in interproximal surfaces. Eur J Dent 2008;2(2):96-101.
25. Gedik R, Hurmuzlu F, Coskun A, Bektas OO, Ozdemir AK. Surface roughness of new microhybrid resin-based composites. J Am Dent Assoc 2005;136(8):1106-1112.
26. Lambrechts P, Vanherle G. Structural evidences of the microfilled composites. J Biomed Mater Res 1983;17(2):249-260.
27. Strassler HE, Porter J. Polishing of anterior composite resin restorations. Dent Today 2003;22(4):122-128.
28. Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. J Am Dent Assoc 2003;134(10):1382-1390.
29. de Moraes RR, Goncalves Lde S, Lancellotti AC, Consani S, Correr-Sobrinho L, Sinhoreti MA. Nanohybrid resin composites: Nanofiller loaded materials or traditional microhybrid resins. Oper Dent 2009;34(5):551-557.
30. Sharif MO, Catleugh M, Merry A, Tickle M, Dunne SM, Brunton P, Aggarwal VR. Replacement versus repair of defective restorations in adults: Resin composite. Cochrane Database Syst Rev 2010;2:CD005971.
31. Turssi CP, Ferracane JL, Serra MC. Abrasive wear of resin composites as related to finishing and polishing procedures. Dent Mater 2005;21(7):641-648.
32. Behle C. Placement of direct composite veneers utilizing a silicone buildup guide and intraoral mock-up. Pract Periodontics Aesthet Dent 2000;12(3):259-266.
33. Lopes GC, Vieira LC, Araujo E. Direct composite restorations: A review of some clinical procedures to achieve predictable results in posterior teeth. J Esthet Restor Dent 2004;16(1):19-31.
34. Albers HF. Tooth colored restorations: Principles and techniques, ed. 9. London: BC Decker Publishing Company;2002.
35. LeSage BP. Aesthetic anterior composite restorations: A guide to direct placement. Dent Clin North Am 2007;51(2):359-378.
36. LeSage BP, Milnar F, Wohlberg J. Achieving the epitome of composite art: Creating natural tooth esthetics, texture, and anatomy using appropriate preparation and layering techniques. J Cosmet Dent 2008;24(3):42-51.
37. Jacobsen T. Resin composite in minimally invasive dentistry. Oral Health Prev Dent 2004;2(Suppl 1):307-311.

Manufacturers

Bisco, Inc., Schaumburg, IL
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Brasseler USA, Savannah, GA
800.841.4522, www.brasselerusa.com

Cosmedent, Inc., Chicago, IL
800.621.6729, www.cosmedent.com

Heraeus Kulzer, Inc., Armonk, NY
800.431.1785, www.heraeus-dental-us.com

Exercise No. 291

Cosmetic Dentistry

Subject Code 780

The 15 questions for this exercise are based on the article "Finishing and polishing criteria for minimally invasive composite restorations" on pages 422-428. This exercise was developed by Thomas C. Johnson, DMD, MAGD, in association with the *General Dentistry* Self-Instruction committee.

Reading the article and successfully completing the exercise will enable you to:
- understand the advantages of current composite resin formulations;
- understand the importance of proper finishing and polishing;
- learn a technique for tooth preparation and the handling and placement of composite resins; and
- learn a technique for finishing and polishing composite resins.

1. Which of the following could be a result of improper finishing and polishing?
   A. Increased tactile awareness
   B. Reduced wear kinetics
   C. Reduced abrasiveness
   D. Increased rate of recurrent caries

2. What is meant by the term *finishing?*
   A. The last step in the protocol of creating a smooth surface
   B. Gross contouring or reduction
   C. Reduction in roughness and scratches
   D. Use of aluminum oxide pastes

3. What is the threshold surface roughness where no further reduction in bacterial accumulation can be obtained?
   A. 0.75 microns
   B. 0.50 microns
   C. 0.20 microns
   D. 0.10 microns

4. What can cause sub-surface micro-cracks, crazing, and cracking of the composite surface?
   A. Dry polishing
   B. Using the wrong polishing paste
   C. Trying to accomplish gross reduction with fine diamonds
   D. Use of carbide laminated burs or coarse diamonds

5. What is the smallest difference in surface roughness that can be detected by a patient's tongue?
   A. 0.10 μm
   B. 0.20 μm
   C. 0.30 μm
   D. 0.40 μm

6. Which of the following is true regarding different brands and classes of composite restorative materials?
   A. Hybrid composite resins are best finished with wet finishing diamonds.
   B. Finishing systems from the same manufacturer achieve a smoother surface and less staining.
   C. Microfill composite resins are best finished with 12 or 30 fluted carbide burs.
   D. Microfill composites should not be polished with aluminum oxide pastes.

7. Which of the following is true of microhybrid composite resins?
   A. Less strength with functional stresses
   B. High level of translucency
   C. Less resistant to surface micro-cracks
   D. Loses surface gloss and is less stain-resistant

8. Which of the following is true of microfilled composite resins?
   A. Maintains surface gloss, yet stains easily
   B. Less resistance to wear and abrasion
   C. High strength with functional stresses
   D. Opacity similar to that of dentin and enamel

9. Which of the following is true of nanofilled composite resins?
   A. Less strength with functional stresses
   B. Translucency is too great
   C. Less resistant to surface micro-cracks
   D. Maintains surface gloss and is stain-resistant

10. Which of the following is true regarding finishing and polishing nanofilled composite resins?
   A. They are best finished with wet finishing diamonds.
   B. They finish well regardless of the system used.
   C. They are best finished with 12 or 30 fluted carbide burs.
   D. They should not be polished with aluminum oxide pastes.

11. Minimizing adjustments after composite placement makes finishing and polishing simpler and more predictable. Tooth reduction guides and a matrix providing placement limits facilitate this goal.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

12. Creation of an undetectable margin involves all but which of the following?
   A. Use of a sunburst bevel in preparation design
   B. Etching and bonding to extend beyond the bevel
   C. Rolling the composite prior to placement
   D. Super-curing the composite and allowing it to "relax" for at least five minutes

13. Which of the following produces the lowest incidence of defective margins?
   A. Goat-hair chamois brush
   B. Coated abrasive discs
   C. Cross-cut regular fissure burs
   D. Fine, extra-fine, and ultra-fine diamonds

14. Which of the following is included in the armamentarium for creating texture and anatomy?
   A. Flap door matrix
   B. Goat-hair chamois brush
   C. Aluminum oxide polishing paste
   D. Diamond polishing paste

15. A system from the same manufacturer that incorporates polishing paste, points, cups, wheels, and silicone brushes is recommended for esthetic direct composite restorations. The use of an assortment of polishing instruments has been shown to produce less variation in surface roughness after polishing.
   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.

Instructions are on page 431.
Answer form is on page 511.
Answers for this exercise must be received by October 31, 2012.

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3 mm can save your case: Making beauty function

Steve Ratcliff, DDS, MS ▪ Lee Ann Brady, DMD

Understanding esthetic design is not enough if restorations are to withstand the forces of function. Dentists also must understand the relationships of incisal tables, the interincisal angle, disclusion forces, and the implications of changing those parameters when restoring the anterior dentition. While canine-protected occlusion is often a goal, it may not always be appropriate or attainable. This article describes the details of creating a functional anterior design that will not only be beautiful but will have the best chance of withstanding parafunctional activity and abnormal force.

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When restoring anterior teeth, the parameters of smile design are well-understood and have been described in both the dental and medical literature.[1,2] Occlusion, however, remains a controversial topic, sometimes heatedly so, most likely because the differing philosophies all provide some degree of success. With success comes confidence and the certainty of being "right." Yet breaking restorations, abnormal wear, muscle pain, loose teeth, and lost implants all have been implicated as part of occlusal disease.[3,4]

Indiscriminately altering the shape of teeth for the sake of improving esthetics brings well-known sequelae, especially in those patients who have parafunction or a history of bruxism. Understanding some of the basics of anterior guidance as well as the anterior and posterior anatomy of teeth lends confidence that esthetic restorations are also stable, functional, and can last for reasonable periods of time. This article examines three anatomic areas of teeth relative to occlusal principles: marginal ridges, interincisal angulation, and incisal tables.

The accepted thinking in restorative dentistry advocates bilateral canine guidance with immediate and complete posterior disclusion as the therapeutic norm. There is substantial support in the literature for using this widely accepted occlusal scheme, based mostly on muscle activity of the large elevator and to a certain degree the lateral pterygoid muscles.[5-7] However, after examining the dentition for naturally occurring bilateral canine guidance, the reported incidence ranges from 2.3–12.7%.[8] Epidemiologically, that range of occurrence makes bilateral canine guidance abnormal. Should dentists strive to achieve it in every restorative case?

While the parameter of bilateral canine guidance is important in most restorative cases, some nuances exist that should be taken into consideration to give restorative cases the optimal chance for survival. Dawson has described the need for "freedom in centric," and other occlusal disciplines discuss long centric and freedom from centric.[9] While the definitions are diffuse, patients frequently need to have the palatal surfaces of anterior teeth relieved after they have been restored to avoid feeling as though they are hitting their front teeth harder than the back teeth. The need for this freedom often manifests as fremitus when patients tap their teeth, or report that their front teeth "hit hard" or feel "high," or when they complain of bumping their front teeth when eating. Most often, occlusal reshaping occurs with patients lying back; when they sit up, they frequently will feel heavier anterior contact (Fig. 1).

Lightening occlusal contacts on anterior teeth so that they are lighter than posterior teeth when the teeth are touching removes contacts that are on inclines. For immediate canine disclusion to occur, the maxillary and mandibular canines must be in intimate contact at the onset of lateral movement.

Fig. 1. Postural freedom, or freedom in centric.

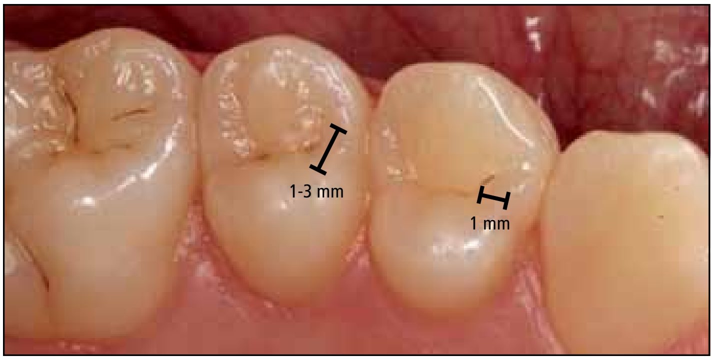

Fig. 2. Natural marginal ridges are landing areas for opposing cusps and anatomic pathways for them.

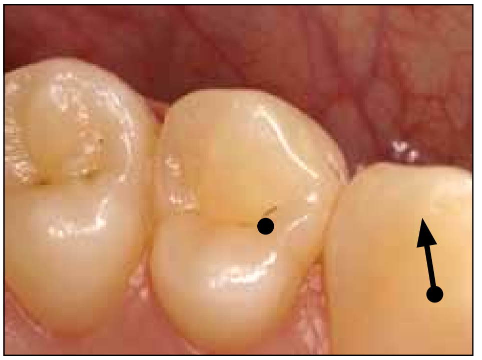

Fig. 3. Marginal ridges can be engaged in lateral movements.

Fig. 4. Green mark showing initiation of lateral movement on the marginal ridge of a premolar.

Fig. 5. The red circle denotes the centric stop; the green halo is the slight lateral stroke before the canine is engaged.

Fig. 6. Fractured first premolar. Note the remants of steep inclines instead of a wide marginal ridge.

Another way to describe it is when the canines are touching when the teeth are together and do not lose contact until another tooth gets in the way or the lateral movement exceeds the length of the canines, and that during that movement, no back teeth touch.

If freedom in centric is required and the anterior teeth are slightly out of contact in maximal intercuspal position (MIP), then when lateral movement begins, posterior teeth will be in contact until the canines are engaged. In other words, the mandibular posterior cusps slide against the maxillary marginal ridges for 0.5–1.0 mm until they engage the canines. The anatomy of healthy marginal ridges demonstrates a mesiodistal dimension of approximately 1.0 mm and a buccolingual dimension of 1.0–3.0 mm (Fig. 2).

The first millimeter that can "save" cases utilizes the natural anatomy of the marginal ridge. Observing the marginal ridges shows a natural flat area for the opposing cusp to slide against until the canines or appropriate discluding teeth engage and separate the posterior teeth. The red circle represents the mark made in the MIP and the green circle around that mark is the distance the opposing cusp slides before the canines engage (Fig. 3–5).

If that flat area is not built into the case or occlusal organization, the danger is in creating incline contacts or locking up the bite. The anterior freedom remains, but now the posterior teeth are prohibited from functioning smoothly, with the result being fremitus or functional mobility. It is not by chance that the maxillary first premolars are the most common virgin teeth to fracture. They frequently have a marginal ridge that is short and narrow, resulting in steep inclines and a wedging effect when the mandibular tooth comes into contact and compressive force such as clenching is applied (Fig. 6).

Occasionally, it is not possible to couple the canines, so guidance must begin on premolars, or, in the case of bruxers or to protect anterior porcelain, the choice is made to create group function. Group function is

Fig. 7. Progressive engagement of excursive movements beginning on the second premolar, then transferring to the first premolar, and finally, the canine.

Fig. 8. Veneer placed to lengthen a canine subsequent to wear from parafunction.

Fig. 9. Patient clenches and begins lateral movement, causing the contact to open as a result of functional mobility.

Fig. 10. The interincisal angle.

particularly advisable in patients with bruxism, since the force exerted on individual canines is up to 10 times greater than with a group function.[9]

Group function also has been described as progressive engagement, or a sharing of anterior guidance that gradually moves from the posterior teeth to the canines (Fig. 7). As the mandible progresses through the excursive movement, the first tooth to engage is a molar or premolar; as the movement continues, the anterior guidance moves forward to the next tooth and leaves the previous tooth. The process continues until the canine is reached.

Group function shares the load of the movement and prevents isolated shear stress on a single tooth. Indications for group function are chronic nocturnal bruxing, single implants in the canine position, structurally weak canines, canine pontics in long-span fixed partial dentures, and chronic joint pain on the working side.

The second millimeter requiring attention is the interincisal angle, or the angle of disclusion. The steepness of this angle can be compared to walking up a hill: the steeper the hill, the more work required to get to the top; the steeper the interincisal angle, the more work required to move into excursion.

When the angle is too steep and the patient is a bruxer and engages in parafunction, the teeth or restorations can break, wear, loosen, or move over time. Weinberg and Kruger demonstrated that a 10 degree increase in the intercuspal angle resulted in a 35% increase in force, while a 20 degree increase resulted in double the force in excursive movements.[9]

The result of canines being lengthened without consideration for the patient's chewing stroke or the envelope of function can be seen in cosmetic cases when canines are designed with a more youthful appearance. The laws of physics note that generating movement requires more force than maintaining that movement. Moving into excursion with steep interincisal angles generates significant force and, if the angles are too steep, could prevent

Fig. 11. Opening the incisal third of the maxillary canine can flatten the interincisal angle.

Fig. 12. The area of the canine to be altered to "flatten" the anterior guidance.

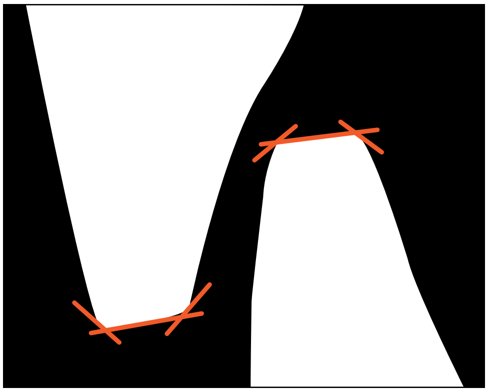

Fig. 13. The pitch and bevel of the incisal table.

the patient from moving past the canines and result in a "locked-up" bite. These patients often are the ones who, when asked to move right or left, will exhibit functional mobility of teeth.

Figure 8 shows a veneer that was placed to lengthen a worn canine. When asked to move into excursion, the patient was unable to move more than 1.0–2.0 mm because she was locked. She developed both muscle soreness, from pushing against her anterior teeth, and functional mobility (Fig. 9). If steeper incisal angles create more force during excursive movements, then keeping the angle of disclusion as flat as possible while avoiding excursive interferences keeps the muscle activity necessary to move into excursion to a minimum. (Fig. 10 and 11). Changing the angle of disclusion could be as straightforward as flattening the palatal surface of the incisal third of the maxillary canines (Fig. 12) or the facial surface of the mandibular canines.

The third millimeter is the incisal form of the anterior teeth. The term *incisal table* is applicable, because creating a smooth anterior guidance requires flat, well-refined surfaces that can glide against each other. As teeth erupt, the mamelons abrade away and the form of the incisal table takes shape. The shape of the incisal table is relevant if the patient is engaging in parafunctional activity and creating wear patterns. In the presence of wear and parafunction, refining incisal tables lowers the friction generated when they rub together and could slow the rate of wear.

Understanding the morphology of the incisal table is critical to creating smooth anterior guidance. The incisal table has three components: the pitch, or flat part of the table; the leading edge that is a functional edge; and the trailing edge that is engaged during parafunction. The leading edge is the facialincisal line angle of the mandibular anterior teeth and the linguoincisal line angle of the maxillary anterior teeth. The trailing edge is the linguoincisal line angle of the mandibular anterior teeth and the facialincisal line angle of the maxillary anterior teeth (Fig. 13).

Leading edges are defined as functional because they move against the opposing surfaces during the closure path of chewing, swallowing, and speech. Trailing edges contact only during parafunctional activity, such as edge-to-edge or extreme excursive movements that occur during bruxing. The pitch of the incisal table should be angled slightly so that it mirrors the incisal table of the opposing anterior tooth and it should be flat enough so that the surfaces can slide against each other with a minimal amount of resistance (Fig. 14 and 15).

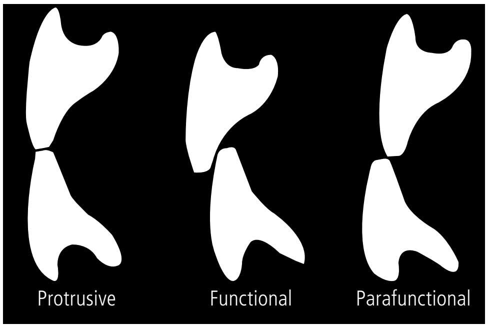

Fig. 14. Incisal table relationships.

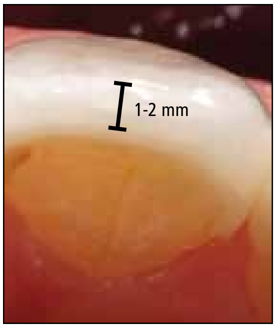

Fig. 15. A well-defined incisal table.

Fig. 16. Wear on incisal tables and incisal line angles of anterior teeth. Note that chipping is present.

Fig. 17. Highly polished bevel of the labioincisal line angle.

Fig. 18. Protrusive movement showing mirroring of the incisal tables.

Fig. 19. Lateral movement on the incisal tables.

Fig. 20. Canines moving into canine rise; flat anterior guidance is demonstrated by the anterior teeth almost touching.

Observing wear in anterior teeth often shows that the leading and trailing edges have worn into knife-edges and could have splintering or small chips missing from those edges. The sharper and thinner the edges become, the more susceptible they are to breaking (Fig. 16).

Incisal tables can be refined by reshaping and polishing or by replacing them with composite or indirect restorations. The incisal table should be broad enough to match the opposing tooth, and the leading and trailing edges should become a highly polished bevel. When the incisal tables contact one another in a protrusive state, they should match and be able to glide in lateral directions smoothly. This is especially important in patients who parafunction only in an anterior-posterior direction or in end-to-end bruxers.

Whether working on the natural dentition or ceramics, the final refinements can be done with rubber wheels. The final bevel is very narrow and barely perceptible, yet this minor nuance can significantly reduce resistance when anterior teeth are moving against one another (Fig. 17).

The final result of occlusal design should be well-refined anterior guidance that allows smooth movement of the mandible without undue restriction. When the anterior teeth touch, they should do so with minimal resistance in protrusive, lateral, radiolateral, and crossover positions.

Crossover can be defined as the position of teeth when the trailing edges pass over each other in any of the excursive movements. Smooth surfaces are created as a defense against parafunction, which is an inside-out movement that differs from the chewing stroke, which begins in the opposite direction of outside-in. When parafunction occurs, the teeth are in the maximum intercuspal position and move outside to excursive positions. Chewing begins with the patient opening his or her mouth, moving toward a lateral border position, and sliding

Fig. 21. Crossover interference, with the maxillary central incisor picking up the mandibular central incisor on the contralateral side.

Fig. 22. Crossover interference. Note that the mandibular lateral incisor catches against the maxillary canine and allows the patient to "push" or "pull" against the opposing tooth.

the jaw inside to finish by swallowing in the maximum intercuspal position. There is very little tooth contact during chewing. Smooth excursive movement when the teeth are touching reduces both muscle activity and force on the teeth.

Crossover is a parafunctional position that occurs in both protrusive and lateral excursive movements (Fig. 18–21). In the end-to-end position, the leading edge of an anterior tooth moves past the trailing edge of the opposing tooth and "crosses over" so that the trailing edges are more nearly in contact. Patients with bruxism will move into that position and then pull back into the maximal intercuspal position. Failing to adjust the trailing edges so that they are smooth can result in catches and resistance as the mandible moves from outside-in and can result in chips, cracks, broken porcelain, or muscle pain (Fig. 22).

Summary

The nuances of occlusion can be challenging and, if avoided, frustrating for both the clinician and patient. A thorough diagnosis and understanding of creating smooth anterior guidance and anterior movements will help to protect the patient's teeth and investment in restorative dentistry.

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References

1. Rufenacht CR. Fundamentals of esthetics. *In:* Dawson PE. Functional occlusion: From TMJ to smile design. St. Louis: Mosby;2007:20-26.
2. Mahan P, Wilkinson T, Gibb G, Mauderli A, Brannon LS. Superior and inferior bellies of the lateral pterygoid muscle EMG activity at basic jaw positions. J Prosthet Dent 1983;50(5):710-718.
3. Williamson EH, Lundquiest DO. Anterior guidance: Its effect on EMG activity of the temporal and masseter muscle. J Prosthet Dent 1983;4(9): 816-819.
4. Rise C, Sheckholestan A. The influence of experimental interfering occlusal contact on postural activity of the anterior temporal and masseter muscles in young adults. J Oral Rehabil 1983; 9(4):19-25.
5. Ogawa T, Ogimoto T, Koyano K. Pattern of occlusal contacts in lateral positions: Canine protection and group function validity in classifying guidance patterns. J Prosthet Dent 1998;Jul 80(1):67-74.
6. Al-Nimri K, Bataineh A, Abo-Farha S. Functional occlusal patterns and their relationship to static occlusion. Angle Orthod 2010;80(1):65-67.
7. Dawson PE. Functional occlusion: From TMJ to smile design. St. Louis: Mosby;2007:190-195.
8. Korioth T, Hamman A. Deformation of the human mandible during simulated tooth clenching. J Dent Res 1994;73(1):56-66.
9. Weinberg L, Kruger B. A comparison of implant/prosthesis loading with four clinical variables. Int J Prosthodont 1995;8(5):421-443.

Exercise No. 292

Cosmetic Dentistry

Subject Code 780

The 15 questions for this exercise are based on the article "3 mm can save your case: Making beauty function" on pages 432-437. 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 the exercise will enable you to:

- recognize that esthetic changes in the form of anterior teeth that can affect function;
- identify how controlling marginal ridges, interincisal angulation, and the incisal table can enhance the stability of anterior restorations;
- differentiate between canine guidance and group function; and
- understand that by applying basic principles of occlusion to the anatomy of anterior and posterior teeth, the stability, longevity, and function of cosmetic reconstructions can be optimized.

1. Bilateral canine guidance is the therapeutic norm in restorative dentistry. Naturally occurring bilateral canine guidance has a reported incidence of
   A. 2.3–12.7%.
   B. 24.2–37.8%.
   C. 67.5–79.7%.
   D. 85.4–97.6%.

2. Patients with recently restored anterior teeth who need freedom in centric could exhibit or report all but which of the following?
   A. Fremitus when tapping teeth together
   B. Heavier contact on anterior teeth when reclined
   C. Anterior teeth that hit harder than posterior teeth
   D. Anterior teeth that bump when eating

3. Group function might be more advisable in bruxers, since the force exerted on the canines only is up to ____ times greater than the force exerted in group function.
   A. two
   B. six
   C. ten
   D. twenty

4. Indications for group function include all but which of the following?
   A. Single implants in the canine position
   B. Structurally weak canines
   C. Canine pontics in long-span fixed partial dentures
   D. Chronic joint pain on the non-working side

5. When freedom in centric is required, the posterior teeth will be in contact until the canines or appropriate discluding teeth are engaged. If a flat area on the marginal ridges of the maxillary posterior teeth is not created, all but which of the following could occur?
   A. Loss of anterior freedom
   B. A locked-up bite
   C. Functional mobility
   D. Tooth fracture

6. Weinberg and Kruger showed that a 10 degree increase in intercuspal angle resulted in a ____ percent increase in force in excursive movements.
   A. 20
   B. 35
   C. 50
   D. 75

7. To minimize muscle activity needed to perform excursive movements, the angle of disclusion of the anterior teeth should be
   A. as steep as possible while avoiding excursive interferences.
   B. as flat as possible while allowing maximum muscle activity.
   C. as steep as possible while allowing maximum muscle activity.
   D. as flat as possible while avoiding excursive interferences.

8. **The leading edge of the incisal table is composed of**
   - A. the linguoincisal line angle of the mandibular anteriors and the facialincisal line angle of the maxillary anteriors.
   - B. the facialincisal line angle of the mandibular anteriors and the facialincisal line angle of the maxillary anteriors.
   - C. the facialincisal line angle of the mandibular anteriors and the linguoincisal line angle of the maxillary anteriors.
   - D. the linguoincisal line angle of the mandibular anteriors and the linguoincisal line angle of the maxillary anteriors.

9. **The leading edge of the incisal table is engaged in function. The trailing edge of the incisal table is engaged in parafunction.**
   - A. Both statements are true.
   - B. The first statement is true; the second is false.
   - C. The first statement is false; the second is true.
   - D. Both statements are false.

10. **The pitch of the incisal table should be angled slightly to mirror the opposing anterior tooth. The pitch should be flat enough so that the surfaces can slide against each other with a maximal amount of resistance.**
    - A. Both statements are true.
    - B. The first statement is true; the second is false.
    - C. The first statement is false; the second is true.
    - D. Both statements are false.

11. ***Crossover* can be defined as the position of the teeth when the**
    - A. trailing edges pass each other in the chewing stroke.
    - B. leading edges pass each other in any excursive movement.
    - C. trailing edges pass each other in any excursive movement.
    - D. leading edges pass each other in the chewing stroke.

12. **As a patient with bruxism pulls the mandible back from a crossover position, chips and cracks can occur in anterior restorations if the clinician fails to do what?**
    - A. Smooth the trailing edges
    - B. Smooth the leading edges
    - C. Smooth the bevel in the pitch
    - D. Smooth the angle of disclusion

13. **What is the most accurate definition of *chewing*?**
    - A. An outside-in movement that begins in the maximum intercuspal position
    - B. An inside-out movement that begins in the maximum intercuspal position
    - C. An outside-in movement that ends in the maximum intercuspal position
    - D. An inside-out movement that ends in the maximum intercuspal position

14. **Trailing edges contact opposing surfaces during which of the following movements?**
    - A. Bruxing
    - B. Swallowing
    - C. Chewing
    - D. Speech

15. **For what reason is the maxillary first premolar the most common virgin tooth to fracture?**
    - A. The lack of a bevel on the leading edge of the buccal cusp
    - B. A predominance of group function in natural dentitions
    - C. The presence of a short and narrow marginal ridge
    - D. The presence of bilateral canine guidance

Instructions are on page 431.
Answer form is on page 511.
Answers for this exercise must be received by October 31, 2012.

self instruction
CDE 2 HOURS CREDIT

Maximizing esthetic results on zirconia-based restorations

Yi-Yuan Chang, BS, MDS

With a flexural strength of approximately 900–1,100 MPa, zirconium oxide is one of the toughest all-ceramic materials available in dentistry.[1] It can be used to fabricate both single-unit and long-span bridge frameworks. A moderate level of translucency makes it suitable for esthetically demanding clinical cases, such as restoring maxillary anterior teeth. A variety of well-designed porcelain veneering systems allow technicians to apply their artistic skills to create natural, lifelike restorations. A good balance of strength, precision, and translucency allows zirconia-based restorations to accommodate a variety of clinical situations.

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Ceramic restorative materials such as feldspathic porcelain (for example, VM7 [Vident] and Vintage MP [Shofu Dental Corporation]), glass ceramics (for example, e.max [Ivoclar Vivadent Inc.]), and aluminum oxides (for example, Procera AllCeram alumina [Nobel Biocare USA]) all have inherent advantages to translucency and are favored for matching the optical property of natural dentition (Fig. 1). However, the strength of those ceramics has limited their clinical applications to low occlusal force and short-span frameworks.[2]

Zirconium oxides (zirconia) provide superior physical and mechanical properties.[3] Integrated with CAD/CAM technology, they are indicated for long-span bridges and custom implant abutments (Fig. 2). Moderate amounts of translucency will block medium to heavily discolored tooth substructure (Fig. 3). It seems that zirconia is an ideal all-ceramic choice for a variety of clinical applications. However, porcelain chipping and opaqueness are common issues of zirconia restorations.[4] The bond strength between the coping and veneering porcelain is a questionable issue of its surface smoothness. With proper procedures and techniques, it is the author's opinion that these issues can be reduced significantly. This article will further explore other factors affecting the longevity and esthetics on zirconia restorations, such as preparation design, preparation modification using reduction copings, communication between dentist and dental technician, and the artistic process of making all-ceramic restorations.

There are a number of updates on tooth preparation design for zirconia restorations as compared

Fig. 1. Natural dentition (left) contains many characteristics, for example, translucency, mamelon and halo effects, decalcification, and multicolor zones. A properly layered all-ceramic crown can create the optical illusion of being close to natural dentition.

Fig. 2. A five-unit zirconia framework. The surfaces were carefully polished with a diamond-impregnated rubber wheel.

Fig. 3. Medium level discoloration needing to be blocked out. Two zirconia restorations were placed to provide a close shade match, both close-up (left) and at a conversational distance (right).

Fig. 4. Ideally, the preparation includes a circumferential shoulder or chamfer with a horizontal angle of at least 5 degrees. The vertical preparation angle should be at least 3–4 degrees. The inside angle of the shoulder preparation must be given a rounded contour.

Fig. 5. Sharp incisal occlusal edges should be avoided. Sharp line angles should be rounded over. Depending on the CAD/CAM system, the recommended rounding radius should be 0.4 mm.

to conventional porcelain-fused-to-metal (PFM) restorations. To accurately scan the geometry of the preparations, the dentist must create a minimum 3–4 degree taper on both the mesial and distal vertical walls (Fig. 4).[5] The restoration also requires deep chamfer or shoulder margin designs for strength.[6] Lastly, smooth and round preparation surfaces are recommended to minimize internal stress, as force will concentrate on sharp edges and line angles (Fig. 5). When minor modifications and/or additional reductions are needed, reduction copings can be fabricated in the laboratory to serve as an alternative instead of recreating the preparation and retaking a new impression. The dentist can use the reduction coping as a preparation guide to reduce tooth structure in the patient's mouth at the cementation appointment (Fig. 6–8).

A commonly held belief states that less reduction is needed for zirconia restorations. The opacity and thickness of the coping are two reasons that this concept does not apply to zirconia-based restorations. Although moderately translucent, zirconia is just opacious enough that it needs a medium thickness of veneering porcelain to create depth. The average coping thickness is 0.4–0.5 mm, so 1.3–1.5 mm of facial reduction is needed to consistently recreate a desired, life-like porcelain quality that mimics natural dentition. Underpreparation will result in opacious restorations.

Improperly designed copings, especially insufficient support of veneering porcelain, cause porcelain chipping.[7] Zirconia copings must be built up and out when large amounts of tooth structure are removed or missing (Fig. 9). Failure to do so will allow an excessive amount of force overload on the veneering porcelain and eventually could cause it to fracture. It is the technician's responsibility to envision the negative space and build up the coping material when support is needed. This can be done with computer software in a virtual environment or physically waxed up on a working cast and then scanned into a computer.

Surface finishing will maximize the bond strength of zirconia copings. Milling with an industrial CAD/CAM machine leaves various bur marks on the surfaces of copings, which reduces their strength. Manual polishing and finishing the outer surfaces using diamond-impregnated rubber wheels (Meister SC-51, Noritake Dental Supply Co., Ltd.) will remove the bur marks and create

Fig. 6. The reduction coping is made on the original preparation with pattern resin (GC America Inc.).

Fig. 7. The reduction coping is modified to create desired space on the working cast in the dental laboratory. The technician then fabricates the final restoration on the modified preparation. Both the reduction coping and the restoration will be sent back to the dentist.

Fig. 8. The original preparation will be modified using the reduction coping as a guide. Reduction copings work well when additional reduction is needed on the incisal half of the preparation. This technique is insufficient when the gingival half of the preparation needs to be modified.

Fig. 9. Due to implant placement, an excessive amount of labial space needs to be filled on tooth No. 8 (left). A custom-designed zirconia implant abutment, extended labially to fill the space, provides support for veneer porcelain (right).

a more homogenous, denser surface at the microscopic level.[8] Abrasive treatment of that surface should begin with light sandblasting with 50 μm aluminum oxides at 20 psi; this will remove the necessary amount of surface energy and increase the bond between the coping surface and veneering porcelain. An additional step recommended to maximize the bond is the application of a thin layer of bonding agent, followed by firing in a porcelain oven at 1,000°C. Normal porcelain buildup procedures will follow.

Shade communication between dentists and laboratory technicians is a challenge in esthetically demanding cases, especially those involving maxillary anteriors. Natural dentition has a wide color range and is not completely covered by any single shade guide system available today.[9] For this reason, the manual shade-taking process can be challenging. The results are greatly affected by the experience of the shade taker, the tools utilized, and the lighting conditions where the shade taking is taken place. Computerized shade-taking devices, such as Easy Shade (Vident), are a helpful aid chairside, as they effectively reduce environmental variables such as lighting conditions and human error.

Photography is a great tool for recording the shade and communicating it between dentist and technician. Traditionally, the dentist will write down shade prescriptions on a laboratory slip and send it to the laboratory. However, prescriptions often do not precisely describe the characteristics of natural teeth and can easily be misinterpreted by the reader. Accurately captured images will resolve this issue. A digital SLR camera is recommended, coupled with a 100–105 mm macro lens and a dual or ring flash (Canon MT24-EX, Canon U.S.A., Inc.).

White balance is one of the key factors for making accurate color images. As the predominant light source for dental photography is flash light, white balance can be pre-set to match the color temperature of the flash, whether it is on the camera or on the external flash light. The other key factor is proper exposure. A properly chosen light metering system will produce an accurate exposure. Spot metering or a center-weighted meter is recommended for digital SLR cameras.

Fig. 10. Veneer preparations make wax-up try-in more challenging, as the wax-up is often too thin and fragile. A resin framework can be made that is both thin and strong. A colored wax-up is then layered to the top to create desired form and color (middle).

Fig. 11. Because every person's smile is unique, a try-in that allows verification of the designed smile with the patient is valuable.

Fig. 12. In a shade-matching case such as the one shown here, a test crown will allow the technician to verify the porcelain recipe and layering methods. If modifications are needed, they can be made with the final restorations.

A minimum of two images are recommended to best demonstrate crucial shade information to the technician. One image contains the closest matched shade tab(s) placed at the same vertical plane of natural teeth, while the other image is a close-up shot of the existing dentition with a contraster, which separates the oral background from the teeth, generating a tighter focus on the natural dentition. Both images should be taken with the lips retracted. Images can be emailed to the laboratory if downsized to an emailable file size (1.0 MB or smaller is recommended). The JPG file format generates a small file size and provides a good color tone. Adobe Photoshop and Light Room are two software programs for downsizing images.

A try-in process can be added to the treatment plan to ensure that subjective esthetic matters such as smile design and shade are communicated accurately with the patient. The author often uses a colored wax-up and test crown to preview a smile and a custom-designed shade for the patient at the try-in stage before final restorations are completed. A properly layered colored wax-up can mimic shades of the natural dentition, which can be reinforced with a resin framework so that it is strong enough to be tried in the patient's mouth (Fig. 10). The patient can evaluate this 3-D prototype of the final restoration in his or her mouth and provide feedback (Fig. 11). Necessary changes can be made with ease at chairside, as wax can be added or subtracted easily. The technician will then use the modified wax-up as a 3-D index to build porcelain, minimizing guesswork.

Dental porcelain has optical properties that are close to those of natural dentition. Properly layered porcelain crowns can blend very well with natural teeth; however, sophisticated build-up techniques, various porcelain powders, and years of experience are needed to achieve lifelike results. Limited reduction makes it challenging to create multi-layered porcelain crowns. For this reason, shade matching is one of the most difficult tasks in dentistry. Large restorative cases involving multiple teeth are not as challenging as a single-tooth replacement, especially in the anterior esthetic zone.

The author often uses a test crown as a custom shade guide (Fig. 12). The test crown is fabricated in exactly the same manner as the final restoration, using the exact same materials. Doing so will allow the

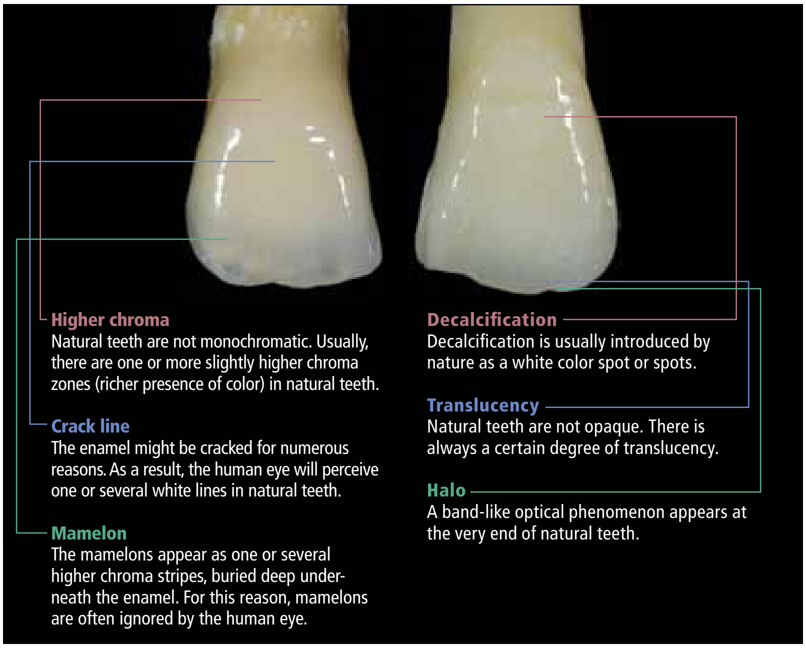

Fig. 13. Some of the often-seen characteristics of natural dentition are displayed.

Fig. 14. Surfaces of natural dentition often are not completely smooth. This surface unevenness can be seen when light hits the tooth at the right angle. Without this unevenness, surfaces of restorations sometimes look overly smooth.

Fig. 15. Properly placed surface textures that mimic those of natural dentition.

Fig. 16. The skeleton buildup technique (courtesy of Ed McLaren, DDS).

laboratory technician to verify the shade before completing the entire case. If the shade is mismatched on the test crown, necessary modifications can be made on the final restoration(s). The key is to document the differences with photographs at a try-in stage and send them to the technician, who can use them to make needed shade modifications on the final restorations. Although using a test crown requires an additional appointment, its use reduces remakes due to shade mismatching, saving both laboratory time and chair time.

Porcelain buildup is arguably the most artistic element in the restorative process. Some of the commonly seen characteristics of natural dentition are multi-chromatic zones, mamelons, translucency, halo effects, crack line(s), and surface textures (Fig. 13 and 14).[10] All of these characteristics can be created with the skeleton porcelain buildup technique, using multiple porcelain powders.[11] Surface textures will be added onto surfaces by grinding with the proper burs (Fig. 15).

Dental porcelain powders are designed in different opacities, chroma, and hues. An artful, precisely controlled blend of these powders in various layers will result in a ceramic crown with an optical illusion close to natural teeth. However, this technique remains an art form, and it is a challenge to achieve the desired optical illusion using man-made materials in limited thickness. Understanding the process will allow dentists to develop an eye for quality restorations and an appreciation of the technician's skill.

The layering procedures of preparing a multilayered zirconia crown are described and illustrated below (Fig. 16): a thin wash layer of highly fluorescent liner porcelain; followed by opacious dentin; followed by translucent dentin; followed by incisal frame, a highly translucent layer serving as the canvas for creating mamelons; followed by various mamelon powders to create finger-shaped internal effects; followed by enamel porcelain; followed by contouring and surface texturing; followed by surface colorants; followed by a glazed final result.

Summary

Zirconium oxide is inherently strong. With sufficient space, a properly designed preparation and coping, and layered porcelain, zirconia-based restorations can provide esthetics in various clinical conditions. The challenge remains for dentists to familiarize themselves with and adapt to new concepts and techniques required for handling zirconia-based restorations to ensure long-term success.

Meanwhile, technicians are responsible for executing the esthetics portion of treatment planning. Using the available space and properly layering the porcelain will create an optical illusion that appears to be lifelike. When combined with natural shape and form, zirconia-based restorations can closely and consistently match natural teeth and create esthetic smiles at a conversational distance.

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Author information

Mr. Chang is assistant director for the laboratory program and an instructor for porcelain layering hands-on courses, UCLA Center for Esthetic Dentistry, Division of Restorative Dentistry, UCLA School of Dentistry, Los Angeles, California.

References

1. Giordano R, McLaren EA. Ceramics overview: Classification by microstructure and processing methods. Compend Contin Educ Dent 2010; 31(9):682-688.
2. White SN, Miklus VG, McLaren EA, Lang LA, Caputo AA. Flexural strength of a layered zirconia and porcelain dental all-ceramic system. J Prosthet Dent 2005;94(2):125-131.
3. Gamborena I, Blatz MB. Surgical and prosthetic technique for single tooth immediate implant placement. *In:* Sadan A, ed. Quintessence of dental technology. Hanover Park, IL: Quintessence Publishing Co., Inc.; 2007:21-31.
4. Al-Amleh B, Lyons K, Swain M. Clinical trials in zirconia: A systematic review. J Oral Rehabil 2010;37(8):641-652.
5. Beuer F, Edelhoff D, Gernet W, Naumann M. Effect of preparation angles on the precision of zirconia crown copings fabricated by CAD/CAM system. Dent Mater J 2008;27(6):814-820.
6. Beuer F, Aggstaller H, Edelhoff D, Gernet W. Effect of preparation design on the fracture resistance of zirconia crown copings. Dent Mater J 2008;27(3):362-367.
7. Pogoncheff CM, Duff RE. Use of zirconia collar to prevent interproximal porcelain fracture: A clinical report. J Prosthet Dent 2010;104(2):77-79.
8. Helvey GA. Zirconia and computer-aided design/computer-aided manufacturing (CAD/CAM) dentistry. Inside Dent 2008;4(4):72-79.
9. McLaren EA, Chang YY. The 3D communication of shade: Visual shade taking and the use of computerized shade-taking technology. Inside Dent 2006;2(1):92-93.
10. McLaren EA, Chang YY. The contrast-zone color system: A porcelain or composite layering system to achieve the illusion of a natural tooth. Inside Dent 2006;2(3):74-75.
11. McLaren EA. The skeleton buildup technique: A systematic approach to the three-dimensional control of shade and shape. Pract Periodontics Aesthet Dent 1998;10(5):587-597.

Manufacturers

Canon U.S.A., Inc., Lake Success, NY
800.652.2666, usa.canon.com

GC America Inc., Alsip, IL
800.323.7063, www.gcamerica.com

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

Nobel Biocare USA, Yorba Linda, CA
800.993.8100, www.nobelbiocare.com

Noritake Dental Supply Co., Ltd., Miyoshi, Aichi, Japan
81.561.32.8953, www.noritake-dental.co.jp

Shofu Dental Corporation, San Marcos, CA
800.827.4638, www.shofu.com

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

Exercise No. 293

Cosmetic Dentistry

Subject Code 780
The 15 questions for this exercise are based on the article "Maximizing esthetic results on zirconia-based restorations" on pages 440-445. This exercise was developed by Merlin P. Ohmer, DDS, FAGD, in association with the *General Dentistry* Self-Instruction committee.

After reading the article and completing the exercise, you will better understand:
• principles of esthetics using zirconia;
• the properties of zirconia; and
• how to opitimally use zirconia.

1. What is the flexural strength of zirconium oxide?
   A. 750–850 mPa
   B. 900–1,100 mPa
   C. 1,200–1,300 mPa
   D. 1,400–1,500 mPa

2. Due to its toughness, zirconia is ideal for single unit restorations. This property makes it unusable in multiple-unit partial dentures.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

3. Which of the following ceramics is the least translucent?
   A. Zirconia
   B. Glass
   C. Feldspathic porcelain
   D. Aluminum oxide

4. Which of the following ceramics is the strongest?
   A. Zirconia
   B. Glass
   C. Feldspathic porcelain
   D. Aluminum oxide

5. All of the following can be negative characteristics of zirconia except one. Which is the exception?
   A. Bond strength to veneering porcelain
   B. Strength of the coping
   C. Chipping of the edges
   D. Opaqueness of the materials

6. All but which of the following are ideal characteristics of a preparation for a zirconia crown?
   A. Three to four degrees of taper mesially and distally
   B. Smooth surface of preparation
   C. Deep champher
   D. Sharp and precise line angles

7. Less reduction is required for zirconia restorations. Under preparation will result in opacious 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.

8. Chipping of zirconia restorations is caused by overload and is reduced by all but which of the following?
   A. Insufficient support of veneering porcelain
   B. Proper design of the coping
   C. Proper occlusion adjustment
   D. Elimination of negative space

9. What should be used to polish zirconia copings after milling?
   A. Diamond burs
   B. Carbide burs
   C. Diamond rubber wheels
   D. Sandblasting with 50 μm aluminum oxide

10. Bond strength of porcelain to coping is improved by all but which of the following?
   A. Using a bonding agent on the coping
   B. Firing the coping to 1,000°F
   C. Sandblasting the coping
   D. Polishing the coping

11. Which of the following is the most accurate means of relaying shade information to the lab?
   A. Using multiple shade guides
   B. Allowing the dental laboratory to decide
   C. Allowing the dental assistant to take the shade
   D. Using a computerized shade guide

12. How can proper anterior esthetics be best enhanced?
    A. Using a colored wax-up and test crown
    B. Using the proper shade guide
    C. Fabricating the final restoration and then staining it
    D. Properly educating the patient

13. What are the most challenging esthetic restorations?
    A. Anterior fixed partial dentures
    B. Anterior single crowns
    C. Anterior multiple crowns
    D. Anterior fixed partial dentures that cross the midline

14. Once a good and accurate shade is determined, how is the porcelain build-up made?
    A. One shade of the chosen porcelain
    B. Reverse stacked porcelain technique
    C. Multiple shades of porcelain
    D. With cast porcelain

15. Dental porcelains are made with all but which of the following characteristics?
    A. Chroma
    B. Hue
    C. Opacity
    D. Contrast

Instructions are on page 431.
Answer form is on page 511.
Answers for this exercise must be received by October 31, 2012.

Successful strategies for matching one or two indirect restorations to natural dentition

Michael R. Sesemann, DDS

One of the most difficult and noble undertakings of a dental restorative team is to provide an indirect restoration for a compromised tooth surrounded by otherwise healthy, natural dentition. Matching one or two indirect dental restorations to adjacent healthy teeth is a herculean task for both the dentist and laboratory technician. The team must be knowledgeable of the natural dentition's characteristics to best mimic and recreate those same characteristics in a man-made restoration. Knowledge of principles in smile design, dental anatomy, color, characterization, material selection, doctor-technician communication, and clinical acumen are necessary to achieve a successful outcome when matching one or two indirect restorations to natural dentition.

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Achieving natural esthetics by harmoniously matching the shape and color of a single anterior restoration is perhaps one of the greatest challenges in restorative dentistry.[1] The advent of lifelike restorative materials has made it possible to supply an indirect restoration that provides optical properties that mimic those of natural teeth.[2] However, the dentist and laboratory technician must work synergistically to identify significant details of the adjacent natural dentition to create an artificial unit that will blend perfectly with its native neighbors.

Not too long ago, when a patient presented with a single anterior tooth problem requiring a restorative solution, the suggested treatment plan would have included the restoration of an adjacent natural tooth or teeth so that all of the anterior teeth in an arch would have matching optical properties. Restoring all of the maxillary incisors when only one tooth was the problem was not unheard of, and the inclusion of a perfectly healthy contralateral central incisor to help disguise the restoration of another central incisor by itself was all too common. One of the greatest benefits of the lifelike materials currently available is the ability to implement a much more conservative treatment plan for the health benefit of patients.

Having improved materials is only one of the important components of success. A successful protocol begins with an accurate examination and diagnosis for a full accounting of the problem. After that, elements of smile design, dental anatomy, color, characterization, material selection and dentist/laboratory communication must be analyzed and applied with a high level of efficiency and effectiveness for the restoration to fulfill esthetic objectives.

Examination, diagnosis, and treatment plan

The value of a comprehensive examination and data collection is well-established and accepted.[3] If a patient has a multitude of issues, data collection will include a full set of radiographs and a photographic survey with impressions and a bite registration for providing mounted study models for analysis. When a patient needs only one restoration, there is a tendency for the clinician to believe that the usual data collection can be scaled back and that the restorative team should be able to get by with less. However, clinical experience has convinced the author that doing so compromises the team's ability to have all of the data needed to match one or two restorations to the patient's natural dentition.

Whether a patient needs one restoration or a full-mouth rehabilitation, complete data collection with a full series of initial images is extremely important.[4] The images should be taken in a timely manner with an effort made to keep the teeth hydrated between frames so that desiccation does not cause a perceptual distortion from how the dentition normally appears. A black background for 1:1 close-up images will help individual tooth characteristics stand out, such as areas of translucence, hypocalcifications, and maverick colors (Fig. 1). A dual flash attachment also prevents light reflection from obscuring the image.

The exposure of the image must be perfect and should never be overexposed, because all of the tooth's characteristics will be concealed in an overly bright image (Fig. 2). In fact, intentionally underexposed

Fig. 1. A close-up image taken at 1:1 magnification with proper exposure and a dual flash apparatus.

Fig. 2. An image of the patient in Figure 1 taken with a ring flash that is overexposed does not show dental characterizations.

Fig. 3. This underexposed image, taken from a side perspective, shows a shade guide with a tooth to be replicated that exhibits diffuse whitish hypocalcifications.

Fig. 4. Study casts of a proposed restoration for tooth No. 9 illustrate a perceived difference in width to the contralateral central incisor.

Fig. 5. Occlusal view illustrating the difference in anatomy. Tooth No. 9 is a restoration whose line angles have been carried far into the interproximal contact area, and the facial profile is convex.

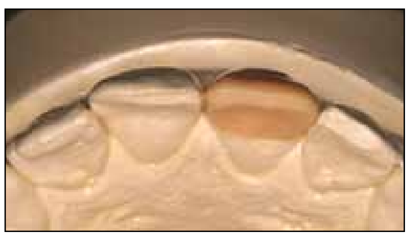

Fig. 6. Occlusal view of a wax-up showing that the restoration can match the contralateral tooth if the line angles and facial contour are replicated.

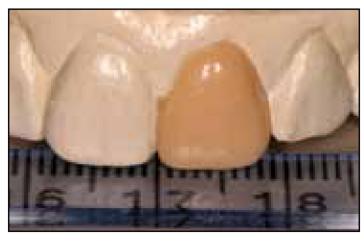

Fig. 7. Straight-on image with millimeter ruler showing the duplicate widths of the tooth and proposed restoration.

images can help the ceramist see distinguishing characteristics that do not appear with images with normal exposure. When taking this shot with a shade guide included for laboratory communication, it is beneficial to have the images of the teeth in the arch taken from an angle on either side and above and below the "straight on" perspective (Fig. 3).

Smile design

When restoring a single tooth in the maxillary arch, smile design principles may or may not come into play. There certainly are healthy smiles considered esthetic without being consistent with a "default application" of smile design principles. This is particularly true when the tooth being restored is a lateral incisor, where bilateral differences between contralateral partners lend an aura of naturalness.[5] Not providing contralateral symmetry can be pertinent when it is not desirable to copy certain characteristics of wear, chipping, or cracks; however, if the tooth being restored is a central incisor, more often the objective is to provide a mirror image of the contralateral natural incisor in terms of its shape, shade, and character.

Smile design principles routinely in play are evident in bilateral spatial considerations, especially between the central incisors. Whether the tooth to be restored lends itself the capability to mimic

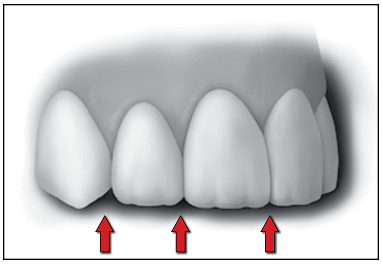

Fig. 8. Incisal embrasures of the anterior sextant should get progressively larger the further they are located from the midline.

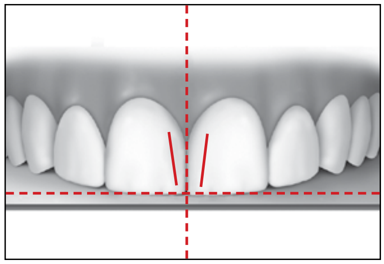

Fig. 9. The mesial line angles of the central incisors frame the most important 18 mm^2 in anterior smile design. Bilateral symmetry is critical.

the contralateral incisor in terms of its spatial presence is of paramount importance. Considerations of height/width proportionality are primary. The use of a diagnostic wax-up can help to determine whether a mirror image of the contralateral central incisor is possible. This is particularly helpful when anatomic differences, such as aberrantly positioned line angles of a previous restoration, can create the perception that the width is greater than it actually is (Fig. 4–7).

Dentitions have a great deal of consistency among the teeth in an arch when the incisal corners of unworn teeth are analyzed and the incisal embrasures are categorized. For maxillary incisors, the respective incisal corners of a given tooth (mesial to distal) can be categorized as square/square, square/round, or round/round. When lined up next to each other, incisal embrasures should become progressively larger when proceeding distally, with the central/central incisal embrasure being the smallest and the lateral incisor/canine being the largest of the anterior sextet (Fig. 8).

Commensurately, the size of the incisal embrasure affects the length of the interproximal contact. As the contacts are analyzed, they can be related to the length of the central incisor as described by Morley and Eubank as the "50:40:30 Rule," with the interproximal contact decreasing in length the further distal one goes.[6]

Management of the periorestorative interface is paramount for controlling height issues.[7] Though the symmetry need not be ideal for all cases, a pleasing gingival architecture can and should be a goal of treatment, and extreme differences should be corrected. Periodontal procedures, including gingivoplasty and/or crown lengthening, are necessary sometimes to increase the clinical crown height of the restored tooth or its contralateral partner.[8] Orthodontic extrusion or intrusion also can be considered for manipulating the tooth's relationship in the arch to shorten or lengthen the clinical crown height as desired.[9]

Dental anatomy

Fabricating a restoration that matches the shape of the adjacent dentition is a vital requirement. Controlling line angle placement, embrasure development (cervical, facial, and incisal), contours, and deflecting/reflecting surfaces are key to mimicking adjacent anatomy. A space for a restoration unequally matched contralaterally can be given that appearance by varying the position of the line angles and controlling the reflective/deflective surfaces.

The cervical embrasures are the primary area of importance in initiating interproximal emergence profiles and line angle development. An interesting presentation occurs with the maxillary lateral incisor: Most of the time, the mesial line angle of the maxillary lateral incisor is located toward the median facial aspect of the tooth at the gingival crest, allowing for a distinctive "opening" of the mesial cervical embrasure. This differs from the line angles of the central incisors.

When restoring a maxillary central incisor, it is extremely important to provide symmetry between the midline and the mesial line angles of the contralateral central incisors.

The line angles must be equidistant to the midline and diagonally similar to provide symmetrical balance (Fig. 9). The midline will appear canted if the line angles are at a different angle or distance from the midline, even if the midline is perfectly aligned with the mid-sagittal of the face. The positioning of the mesial line angles of two adjacent central incisors at the patient's midline might be the most important 18 mm^2 in the maxillary arch, from an esthetic perspective. Also, the line angles of a tooth have a defining relationship to the reflective and deflective areas. The facial surface area between the mesial and distal line angles of a tooth is the reflective surface. The area of the tooth from the line angle to the interproximal contact is the deflective area. If there are differences in the reflective/deflective surfaces of contralateral teeth, they will appear dissimilar.

Reflective and deflective surfaces play a role in the perceived width of a single tooth.[10] Moving the line angles closer to the interproximal contact can make a tooth appear

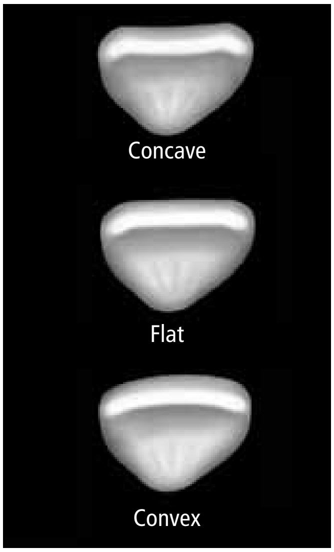

Fig. 10. Perspective of three generalized facial tooth contours for the maxillary incisors.

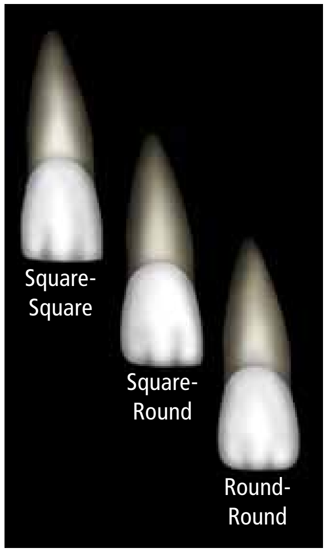

Fig. 11. Illustrations of the three incisal corner presentations of maxillary incisors.

Fig. 12. Before image of a discolored tooth No. 9 and diastema.

Fig. 13. Image showing the different preparation types for a cored restoration (tooth No. 9) versus thinner, more translucent porcelain restorations.

Fig. 14. After image demonstrating the significant laboratory expertise necessary to match a cored restoration to a thin veneer.

wider, because its reflective surface is broader. Conversely, bringing the line angles more medial can narrow the reflective surface, increasing the area of the deflective surfaces and therefore making the tooth appear narrower. There are times when intentional control of these interdependent anatomic details can be used by the restorative team to make restorations appear to be wider or narrower. In a different context, changing the line angles of a faulty restoration can make it match a contralateral natural tooth perfectly.

The contour of the facial surface of a maxillary incisor can be convex, flat, or concave (Fig. 10). When the facial contour is related to the variations of incisal corners, restorations can have completely different "attitudes" in their presentation (Fig. 11). For example, for a bold look, a restoration could exhibit square/square corners and a concave profile. For a softer appearance, round/round corners with a convex facial surface would be the best choice. Of the nine different variations that can occur when the three facial contours are combined with the three different incisal corner variations, the one most often seen and utilized is the combination of square/round corners and a flat facial contour.

Color

Most dentists practice analyzing color in the 3-D modalities of hue, chroma, and value.[11,12] However, a fourth dimension is particularly important in achieving success. The optical properties of opacity must be duplicated for a restoration to mimic a natural tooth accurately. In addition to being a primary element of how a restoration appears, controlling the opacity is critical to blocking out underlying tooth structure, particularly if there is an unwanted discoloration, so that it does not influence the restoration's final "shade" (Fig. 12–14).

Fig. 15. A patient with a tetracycline-stained dentition in need of a single central incisor restoration.

Fig. 16. A digital grey card allows the technician to correct an image to neutral grey with a variety of software options.

The dental team must be fully aware that if a core is provided, the restoration will have to provide 100% of the optical appearance of the restoration. When a core is not needed and the stump shade of the prepared tooth is normal, the team can utilize a more translucent porcelain that works in conjunction with underlying healthy tooth structure to mimic the optical properties of natural teeth. Combining two different types of restorations to look alike while side by side requires extreme skill and expertise on the part of the laboratory technician and diligent communication between the dental office and the laboratory.

Characterization

Incisal translucency, the incisal halo, hypocalcifications (white and discolored), maverick colors, and anatomic irregularities all play a role in the characterization of a restoration.[13,14] The inclusion of characterizations in a restoration helps it to blend sublimely with its natural neighbors, while an absence of proper characterizations spotlights the restoration as an imposter.

Translucency must be incorporated into the varied optics of the tooth to duplicate the gradual thinning and ultimate elimination of dentin in the incisal third of the tooth. Of particular importance is identification of the nature and degree of the incisal translucency and definition of the amount of the incisal halo (the whitish line at the incisal edge). Patients also will have different incisocervical lengths of translucency, and the nature of the translucency can range from clear to smoke to frost. The lobes of dentin seen through the incisal enamel can appear in a variety of ways, including a tri-lobed appearance. In other presentations, the main lobes can be divided further into smaller entities, giving the dentin component an appearance similar to the tines on a comb. There also could be a gradual thinning of the dentin, yielding little detail beyond a simple fade.

For a vast majority of the time, less is more when incorporating characterizations into a restoration. Hypocalcifications can vary from a diffuse "netting" to deeper blotching with varying intensities. Maverick colors of brown, amber, or orange may be present, or seen only during a magnified examination. However microscopic their size, the presence of maverick colors contributes to the tooth's overall appearance.

There are times when maverick colors can become dominant in their appearance, such as in a case of matching a central incisor in a tetracycline-affected dentition. Hues of grey, violet, amber, and brown become primary instead of secondary because of their dominance. In cases like these, communication with the laboratory technician must include details such as duplicate custom provisionals, with one of these being photographed on the patient and sent with the case to the dental laboratory for the ceramist to see exactly what was in the image (Fig. 15–18).

Material selection

There has never been a greater range of material choices available for the practitioner and the laboratory technician/ceramist. This is both a blessing and a curse, because finding the perfect material requires the restorative team to eliminate potential materials through their knowledge of each product's characteristics, attributes, and potential shortcomings. At times, the choice of material might simply reflect what the restorative team does best—it is the product with which the team is most familiar and believe they do their most predictable work.

Fig. 17. A shade tab image for the laboratory includes a custom-made acrylic veneer to enable the technician to have a replica of the one shown in the image.

Fig. 18. Post-treatment image of the crown restoration of tooth No. 9.

However, the patient is best served when the team is accomplished in multiple material applications and can choose the material that is best for the case.

The range of materials can include feldspathic, leucite-reinforced, and lithium disilicate porcelain, along with zirconia and porcelain-fused-to-metal (PFM) options. Due to the intricacies of the esthetics needed in the anterior region, the restoration likely will include ceramic layering so that finite esthetics and characteristics can be built into the appearance. Notable differentiating factors for the restorative team would include the restoration's thickness upon completion and the color and shade of the prepared tooth that will reside underneath the restoration.[15]

At one end of the spectrum, where conservative preparation and normal tooth stump shade are factors, feldspathic, leucite-reinforced, and lithium disilicate porcelain can work. At the other end of the spectrum, where a conventional preparation is made and/or the shade of the underlying tooth needs to be prevented from showing through, a cored product like lithium disilicate or a zirconia would be the best choice. In addition, PFM restorations can work to block out a darkened tooth; however, the expertise of the laboratory ceramist and the chosen final shade must be taken into consideration. A laboratory technician must possess considerable expertise to make a PFM mimic the optical characteristics of a natural tooth. When 100% block-out is warranted and the final shade of the restoration is darker than an A3 value, it might actually work to the technician's advantage to build off a darker core of metal than from a zirconia product that is inherently bright, even with color modification.

Dentist-laboratory technician communication

In addition to the dentist/laboratory technician team being a collaborative partner in material selection, there are communication needs to minimize errant attempts at fabricating the restoration. Protocol requirements include adequate preparation for the type of material chosen, accurate impressions, good photography of the patient's initial conditions, shade images, and provisional models that illustrate an approximate final result.

As stated earlier, it can be beneficial to control the exposure of shade images so that they are not overexposed and, sometimes, to provide underexposed images. The images should be in an RAW format to provide the fullest tonal spectrum possible. An important addition when taking shade images is the use of a digital grey card. With a "neutral grey" hue in one or all of the images, the ceramist has the opportunity to correct the temperature and tint of the image with iPhoto (Mac) or Adobe Photoshop (Mac or PC) on the monitor to calibrate the entire tonal range of the image to the known neutral grey tone included (Fig. 16). This can make the image seen at the laboratory more closely approximate what the teeth and gingiva look like in the operatory.

Clinical acumen

As stated earlier, it remains a key challenge to achieve natural esthetics by harmoniously matching the shape and color of a single anterior restoration. This challenge requires the restorative team to be fully cognizant of nature and the patient's presenting conditions to fabricate a restoration that appears

Fig. 19. A young patient seeking a conservative treatment option to replace an unpleasant restoration on tooth No. 9.

Fig. 20. 1:2 magnification view of the patient's natural smile.

Fig. 21. 1:2 magnification of the patient's upper and lower arches.

Fig. 22. 1:1 magnification of patient's maxillary incisors, revealing anatomic differences between the defective restoration and the contralateral natural incisor.

similar to natural teeth. To match one or two restorations successfully to natural dentition, the restorative team must pay more attention to detail than when fabricating a row of restorations where everything is made to match. To do otherwise is setting up the team and the patient for frustration, failure, or both.

Case report

A 19-year-old woman in excellent health came to the dental office seeking to have a restoration for tooth No. 9 replaced (Fig. 19 and 20). Reportedly, the crown had been in service for only three months. Clinically, there was a great shade disparity between the crown and the adjacent natural teeth; however, the crown was closer to the shade of the mandibular teeth, raising suspicion of localized, unsupervised bleaching of the upper arch after the prior dentist had seated the restoration (Fig. 21). The patient denied that any such actions had taken place and maintained that the crown's current appearance was similar to how it appeared the day it was seated.

A complete examination and data collection revealed the current crown to be a full-coverage crown. There seemed to be more of a potential space for a restoration on tooth No. 9, especially in width, than was present on the contralateral natural central incisor (Fig. 22). A diagnostic wax-up revealed that a new restoration indeed could mimic the contralateral central tooth perfectly (Fig. 4–7).

Both the maxillary and mandibular dentitions were bleached under supervision to control the outcome and to more closely align the value (brightness) of the upper and lower arches. The tooth was prepared for a full crown and supporting data were collected and sent to the dental laboratory for restoration fabrication. At the try-in for the first attempt, further photographic images were taken and sent to the laboratory with the crown so that characterization could be completed (Fig. 23). At the second try-in, the esthetic objectives of the doctor, laboratory technician, and patient were realized and the crown was bonded utilizing a three-step etch and rinse bonding system

Fig. 23. First try-in attempt of the restoration. New images were obtained to allow the laboratory technician to more definitively customize the restoration.

Fig. 24. Facial view of the patient's new smile three weeks after bonding of the restoration.

Fig. 25. 1:2 magnification of patient's natural smile.

Fig. 26. 1:1 magnification of the new crown, exhibiting hypocalcifications, maverick colors, translucencies, and anatomic detailing.

(Optibond FL, Kerr Corporation) and a photocure-only resin cement (Variolink, Ivoclar Vivadent Inc.). Three weeks after cementation, the patient returned for the restoration to be checked and photographed (Fig. 24–26).

Summary

One of the greatest benefits the dental profession can provide patients is the ability to restore a single tooth to match an otherwise healthy and esthetic dentition. The chances of a successful outcome for these challenging cases can be improved by approaching the case with a complete knowledge of anatomical considerations and a predetermined protocol to maximize efforts.

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References

1. Fahl Junior N. The aesthetic composite anterior single crown restoration. Pract Periodontics Aesthet Dent 1997;9(1):59-70.
2. Spear F, Holloway J. Which all-ceramic system is optimal for anterior esthetics? J Am Dent Assoc 2008;139 Suppl:19S-24S.
3. Dawson, PE. Evaluation, diagnosis, and treatment of occlusal problems, ed. 2. St. Louis: Mosby;1989:1-13.
4. American Academy of Cosmetic Dentistry. Photographic documentation and evaluation in cosmetic dentistry. A guide to accreditation photography. Madison, WI: American Academy of Cosmetic Dentistry;2009.
5. Rosenstiel SF, Ward DH, Rashid RG. Dentists' preferences of anterior tooth proportion: A web-based study. J Prosthodont 2000;9(3):123-136.
6. Morley J, Eubank J. Macroesthetic elements of smile design. J Am Dent Assoc 2001;132(1): 39-45.
7. Rufenacht C. Principles of esthetic integration. Landshut, Germany: Quintessence Publishing Co.;2000:37-60.
8. Kois JC. Altering gingival levels: The restorative connection. Part 1. Biologic variables. J Esthet Dent 1994;6(1):3-9.
9. Camargo PM, Melnick PR, Camargo LM. Clinical crown lengthening in the esthetic zone. J Calif Dent Assoc 2007;35(7):487-498.
10. Rufenacht C. Fundamentals of esthetics. Chicago: Quintessence Publishing Co.;1990:67-127.

11. Munsell AH. A color notation, ed. 2. Baltimore: Munsell Color Co.;1961:15-20.
12. Wood DJ, Shiraishi T, Shinozaki N, van Noort R. Spectral reflectance and color of dentin ceramics for all-ceramic restorations. Dent Mater 2008;24(12):1661-1669.
13. Muia P. Paul Muia explains his four dimensional color system. Quintessence Dent Technol 1983; 7(1):57-62.
14. Muia P. The fourth-dimensional tooth color system. Carol Stream, IL: Quintessence Publishing Co.;1985.
15. Baltzer A. All-ceramic single-tooth restorations: Choosing the material to match the preparation—Preparing the tooth to match the material. Int J Comput Dent 2008;11(3-4):241-256.

Manufacturers

Ivoclar Vivadent Inc., Amherst, NY
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Kerr Corporation, Orange, CA
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Oral involvement of chronic graft-versus-host disease in hematopoietic stem cell transplant recipients

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Oral manifestations are common in patients who are diagnosed with chronic graft-versus-host-disease (cGVHD). These manifestations can present as oral mucosal lesions, salivary gland dysfunction, or reduction of the mouth opening due to cutaneous sclerosis. Although several studies have reported the prevalence of oral involvement in cGVHD, few have reported details of different types and severity of oral lesions of cGVHD, according to the NIH. Furthermore, the authors are aware of only one published study concerning oral manifestations of cGVHD in Brazil. The purpose of this study was to evaluate the prevalence and severity of oral involvement of cGVHD.

Oral evaluation of hematopoietic stem cell transplant (HSCT) recipients was conducted on 22 patients (12 men and 10 women) from December 2007 to May 2009. The following categories were assessed: Age, gender, underlying disease, time postHSCT, history of GVHD, therapy for GVHD, oral lesions, xerostomia, resting salivary flow rate, and mouth opening. Oral lesions were classified according to NIH criteria, and the results were submitted to a descriptive analysis. According to the NIH, patients presented diagnostic (40.9%), distinctive (31.9%), and common (9.1%) features of oral cGVHD. Oral involvement of cGVHD was identified in 81.8% of patients, 68.2% as mucosal lesions and 59.1% as salivary gland dysfunction. Reduced mouth opening was observed in 12 patients (80%), with one case associated with cutaneous sclerosis. Oral involvement was frequent in these patients; for many, it was the first clinical manifestation of cGVHD.

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Chronic graft-versus-host disease (cGVHD) is a major complication in patients with allogeneic hematopoietic stem cell transplantation (HSCT); it can affect many organs.[1] Oral manifestations of cGVHD are common and can present as oral mucosal lesions, salivary gland dysfunction, or reduction of mouth opening due to cutaneous sclerosis.[1-4] Oral pain, xerostomia, and dysphagia are symptoms that have been related to oral manifestations of cGVHD.[5,6] Although several studies have reported the prevalence of oral involvement of cGVHD, few have reported details on the different types and the severity of the different manifestations of mouth condition, according to the NIH.[7-10] Furthermore, few studies have been published regarding the prevalence of oral manifestations of cGVHD in Brazil.[2,4]

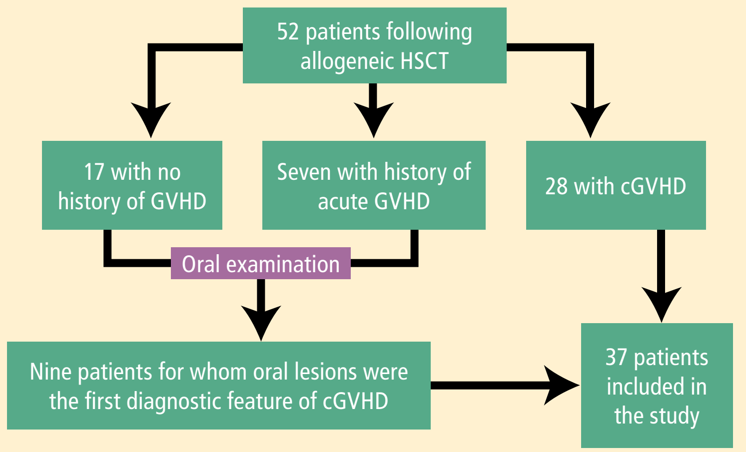
Oral mucosal lesions of cGVHD are similar to those of oral lichen planus, both clinically and microscopically, but they can present a more aggressive clinical course and be more refractory to treatment. Clinical features can present as lichenoid, hyperkeratotic, pseudomembranous, atrophic, edematous, erythematous, or ulcerative lesions.[8,11] Salivary gland dysfunction related to cGVHD can result in xerostomia and superficial mucoceles.[12-14] Patients who develop cGVHD could have a reduction in salivary flow rates (SFR), as well as alterations in the sialochemistry.[15] Scleroderma is characterized by cutaneous sclerosis but also can involve oral tissues. An increased deposition of collagen can occur in patients with cGVHD and lead to a reduction in mouth opening, limited tongue movement, and odynophagia.[4,6] According to NIH criteria, oral manifestations of cGVHD can be classified as diagnostic (lichen-type features, hyperkeratotic plaques, restriction of the mouth opening from sclerosis), distinctive (xerostomia, mucocele, mucosal atrophy, pseudomembranes, ulcers), and common (gingivitis, mucositis, erythema, pain).[1]

The purpose of this study was to evaluate the frequency and severity of oral manifestations in patients with cGVHD in two hematologic centers in Brazil. Oral manifestations were described in accordance with NIH criteria.

Table 1. Clinical and demographic characteristics of patients diagnosed with cGVHD (N = 37).

Variables	*n*	%
Gender		
Male	20	54.1
Female	17	45.9
Age (years)	Mean: 42.47 Median: 43.00 Range: 18–64	
Underlying disease		
Acute myeloid leukemia	15	40.5
Chronic myeloid leukemia	15	40.5
Myelodysplasia	2	5.4
Acute lymphoid leukemia	1	2.7
Non-Hodgkin lymphoma	1	2.7
Hodgkin lymphoma	1	2.7
Aplastic anemia	1	2.7
Multiple myeloma	1	2.7
Time postHSCT (days)	Mean: 1,087.14 Median: 921.00 Range: 159–4,136	
cGVHD prophylaxis		
None	19	51.4
Prednisone	6	16.2
Cyclosporine and prednisone	5	13.5
Cyclosporine, prednisone, and mycophenolate	4	10.8
Cyclosporine	2	5.4
Prednisone and mycophenolate	1	2.7

Chart 1. Flow chart of the inclusion criteria for the 37 patients included in this study.



Materials and methods

A cross-sectional oral evaluation of allogeneic HSCT recipients was conducted at Clementino Fraga Filho University Hospital, Universidade Federal do Rio de Janeiro, and at the Center for Hematology and Hemotherapy, University of Campinas, from December 2007 to January 2011. The study was approved by the institutions' ethics committees and all patients signed an informed consent form.

Age, gender, underlying disease, time postHSCT, history of GVHD, and therapy for GVHD were collected from medical records. A clinical evaluation was performed to assess oral mucosa alterations. Xerostomia, measurement of resting salivary function rate (SFR), and maximum range of mouth opening (RMO) were assessed, as were type, site, severity, and pain associated with oral lesions.

Oral lesions were diagnosed according to clinical aspects and histological examination. Lesions were classified and graded according to NIH criteria for oral cGVHD.[1,16,17] Examinations were performed by one of three investigator specialists in oral medicine. Oral examinations were conducted using an LED at the University Hospital before the physician appointment. Symptoms related to oral lesions were evaluated through a visual analogue scale (VAS). Pain was recorded when the patient reported symptoms greater than zero on the VAS.

Moisture perception also was measured through a VAS. To eliminate eventual cases of dry mouth, xerostomia was considered in cases measuring ≥2.0 cm on the VAS. Resting SFR was used to assess salivary function; saliva was collected under standardized conditions.[18] Measurement of SFR was performed between 9 am and 11 am, and no food, drink, smoking, or hygiene were allowed for 120 minutes prior to this measurement. Patients were instructed to eliminate the accumulated saliva periodically into a cup, and a graded syringe was used to quantify the saliva. Only the liquid component (not the foam) of the saliva was measured. SFRs ≥0.3 mL/minute were considered normal.[19]

RMO was defined as the vertical distance between the maxillary and mandibular central incisors when the mouth was opened completely. This measurement was performed using a calibrated caliper.

Table 2. Prevalence of oral features of cGVHD according to NIH criteria.

Variables	*n*	%
Diagnostic features		
Hyperkeratotic plaques	15	40.5
Lichen-type features	12	32.4
RMO from sclerosis	2	5.4
Distinctive features		
Mucosal atrophy	22	59.5
Xerostomia	22	59.5
Ulcers	14	37.8
Mucocele	10	27.0
Pseudomembranes	2	5.4
Common features		
Erythema	20	54.1
Pain	17	47.2

Table 3. Prevalence of anatomic sites most commonly involved with oral lesions of cGVHD.

Oral anatomic site	*n*	%
Buccal mucosa	24	64.9
Gingiva	23	62.2
Tongue	21	56.8
Hard palate	12	32.4
Lips	11	29.7
Labial mucosa	10	27.0
Soft palate	6	16.2
Floor of the mouth	3	8.1

RMOs <35 mm were considered reduced.[20] Results were submitted to a descriptive analysis.

Results

A total of 52 allogeneic HSCT recipients (25 men [48.1%] and 27 women [51.9%]) were examined. Seven patients had been diagnosed previously with acute GVHD, 28 with cGVHD, and 17 had no diagnosis of GVHD. Nine patients (17.3%) presented oral lesions as the first diagnostic manifestation of cGVHD. After the oral evaluation, 37 patients were diagnosed with cGVHD (Chart 1). Clinical and demographic characteristics of the 37 patients included in the study are summarized in Table 1.

According to NIH classification, 89.2% of the patients presented at least one oral manifestation of cGVHD. Patients were classified as showing diagnostic features of cGVHD in 23 cases (62.2%), while 10 patients (27%) had distinctive oral manifestations of cGVHD. Oral lesions of cGVHD were observed in 30 cases (81.1%), affecting mainly the buccal mucosa, gingiva, and tongue. The prevalence of oral features of cGVHD according to NIH classification is presented in Table 2. Anatomic sites for oral lesions are shown in Table 3.

The median NIH score for the grading of oral lesions was 4.0 (range = 0–12) among the 37 patients studied. With respect to the grading of each clinical presentation, the following lesion median scores were noted: lichenoid, 1.0 (range = 0–3); erythema, 1.0 (range = 0–3); ulcers, 0.0 (range = 0–6); and mucoceles, 0.0 (range = 0–3). The median score for pain from oral lesions on VAS was 1.7 cm (range = 0–8 cm).

No cases of mucositis were identified. According to NIH criteria, mucositis is classified as a common oral manifestation of cGVHD. The patients studied were in a stage of late disease, with the most recent case being 159 days postHSCT, when mucositis is not anticipated. Additionally, gingivitis is considered a common feature by the NIH criteria. Patients in the present study were not submitted to periodontal evaluation with probing, because the study was not designed to evaluate the prevalence of inflammatory periodontal disease.

Salivary gland involvement was identified in 26 (70.3%) of the studied patients: 22 patients (59.5%) had xerostomia, 20 (55.6%) had reduced SFR, and 10 (27.0%) developed mucoceles. Median and mean values for xerostomia were, respectively, 3.0 cm and 3.81 cm on the VAS (range = 0–10 cm). Median and mean SFR were 0.24 mL/min and 0.32 mL/min, respectively (range = 0–0.92 mL/min).

Due to the delayed acquisition of the proper device to measure RMO, mouth opening was measured in only 17 patients. The median RMO observed in this study was 32.5 mm (range = 21–46 mm). Reduced RMO was observed in 13 patients (76.5%); however, only two cases (5.4%) were associated with cutaneous sclerosis (Table 2). No TMJ disorders were observed in these patients.

Discussion

The present study sought to analyze the prevalence of the different types of oral manifestations of cGVHD in accordance with the NIH classification for oral manifestation of cGVHD.[1] Oral involvement of cGVHD was present in 89.2% of the cases, and it was the first manifestation of cGVHD for 17.3% of the patients. These results are similar to those reported elsewhere in the literature, where oral involvement in cases of cGVHD has been reported to occur in more than 70% of the cases, affecting both the oral mucosa and/or the salivary glands.[3-5]

Although several studies have analyzed the prevalence of oral involvement by cGVHD, no study has refined the findings by the anatomic sites and the types and severity of the clinical presentation of cGVHD in the oral mucosa.

The most common clinical presentations of oral lesions in the present study were atrophy, erythema, hyperkeratosis, ulcers, and lichenoid lesions. This result is similar to those considered by previous studies as the main oral clinical manifestations of cGVHD.[4,16] Interestingly, even in the presence of ulcers, atrophy, and erythema, pain scores as noted using a VAS were low. These findings could be explained by the fact that most of the patients were considered to have late-stage disease at the time of the oral examination, with no activity of cGVHD and in a cicatricial disease stage.

Even though the patients in the present study were in a cicatricial stage of cGVHD, a high prevalence of pain was observed. Since the NIH criteria do not define a threshold for pain, in this study, pain was considered a symptom when the patient reported symptoms greater than zero on the VAS. Therefore, the results expressed in the present study reflect pain or sensitivity to food or spices as reported by the patients, which explains the high prevalence.

The oral mucosa sites most commonly involved with lesions in the studied population were similar to those in previous reports, with a high prevalence of oral lesions on the buccal mucosa and on the tongue.[4,16] Gingival lesions associated with cGVHD also were observed frequently in the present study (62.2%). These lesions could have subtle clinical manifestations and can be misdiagnosed easily if investigators are not specifically trained to look for them. Moreover, a possible overlap of cGVHD-related gingival lesions and periodontal disease could complicate this diagnosis.

Regarding NIH criteria, xerostomia and mucoceles are classified as distinctive oral manifestations of cGVHD.[1] Therefore, when patients have mucoceles or symptoms of xerostomia, the diagnosis of cGVHD requires confirmation by pertinent biopsy, laboratory tests, or imaging techniques in the same or other organs. All patients that had symptoms of xerostomia in the present study had already been confirmed for cGVHD. Therefore, the results presented here can be considered as an accurate clinical estimate of the prevalence of salivary gland involvement with cGVHD.

Salivary gland involvement also has been described as subjective and objective measurements in the current study. Salivary gland involvement was identified in 70.3% of the patients as xerostomia (59.5%), reduced SFR (55.6%), or mucoceles (27%). *Xerostomia* can be defined as the symptom of dry mouth, which can be associated with the objective evidence of salivary gland dysfunction.[21] The NIH criteria consider xerostomia to be a oral manifestation of cGVHD, but not reduced SFR.[1] SFR is a more objective measure of salivary gland dysfunction compared to xerostomia. Additionally, many patients with reduced SFR do not complain of xerostomia; patients may not feel the sensation of dry mouth until there is a 40–50% reduction in resting SFR.[22]

Cutaneous sclerosis due to cGVHD has been described as "...indurated, thickened skin caused by deep and diffuse sclerosis over a wide area."[1] Cutaneous sclerosis has been reported in 15.5% of patients with cGVHD in one longitudinal study.[23] Complaints of RMO related to cutaneous sclerosis have been reported in 5–23% of cases; however, to the authors' knowledge, no study has measured RMO in these patients.[4,24] In the present study, only two (5.4%) of the patients had a reduction in RMO, possibly associated with cutaneous sclerosis.

There are two possible reasons for a reduction in RMO in cGVHD not related to cutaneous sclerosis. First, patients with oral lesions could experience a reduction in RMO due to pain associated with these lesions. Second, a reduction in RMO could manifest earlier in the disease life cycle compared to cutaneous sclerosis. Indeed, the present study observed a high prevalence of reduced RMO (76.5%), but only two cases were associated with cutaneous sclerosis (5.4%). Further research is required to analyze the relationship of cGVHD with RMO not associated with cutaneous sclerosis.

The NIH criteria have not defined which RMO would be considered a diagnostic feature for cGVHD. Various thresholds for the diagnosis of trismus have been proposed.[20,25] The parameter used in this study was the same as that proposed for head and neck oncology patients.[20] Further research is warranted in order to define precise limits for RMO in which it could be considered as a diagnostic feature of cGVHD.

The present study is important to provide evidence of the prevalence, anatomical sites, and severity of the oral mucosal lesions of cGVHD, as well as to refine diagnostic criteria with regard to RMO and salivary gland involvement. It is important for dental professionals to be aware of the clinical characteristics of oral lesions in patients submitted to allogeneic HSCT, which could help to establish an early diagnosis of cGVHD. Future studies are required to provide objective thresholds to evaluate SFR, xerostomia, and RMO as they relate to cGVHD.

Conclusion

The current study found that oral involvement by cGVHD was present in the majority of the studied patients and was the first clinical manifestation of the disease for many of the patients. Oral mucosa and salivary glands are frequently involved with cGVHD.

Acknowledgements

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References

1. Filipovich AH, Weisdorf D, Pavletic S, Socie G, Wingard JR, Lee SJ, Martin P, Chien J, Przepiorka D, Couriel D, Cowen EW, Dinndorf P, Farrell A, Hartzman R, Henslee-Downey J, Jacobsohn D, McDonald G, Mittleman B, Rizzo JD, Robinson M, Schubert M, Schultz K, Shulman H, Turner M, Vogelsang G, Flowers ME. National Institutes of Health consensus development project on criteria for clinical trials in chronic graft-versus-host disease: I. Diagnosis and staging working group report. Biol Blood Marrow Transplantation 2005; 11(12):945-956.
2. Boer CC, Correa ME, Miranda EC, de Souza CA. Taste disorders and oral evaluation in patients undergoing allogeneic hematopoietic SCT. Bone Marrow Transplant 2010;45(4):705-711. Epub 2009 Sep 21.
3. Giaccone L, Martin P, Carpenter P, Moravec C, Hooper H, Funke VA, Storb R, Flowers ME. Safety and potential efficacy of low-dose methotrexate for treatment of chronic graft-versus-host disease. Bone Marrow Transplant 2005;36(4): 337-341.
4. Pereira CM, de Almeida OP, Correa ME, Souza CA, Barjas-Castro ML. Oral involvement in chronic graft versus host disease: A prospective study of 19 Brazilian patients. Gen Dent 2007; 55(1):48-51.
5. Schubert MM, Correa ME. Oral graft-versus-host disease. Dent Clin North Am 2008;52(1): 79-109, viii-ix.
6. Silva MM, Bouzas LF, Filgueira AL. Tegumentary manifestations of graft-versus-host disease in bone marrow transplantation recipients. An Bras Dermatol 2005;80(1):69-80.
7. Busca A, Locatelli F, Marmont F, Ceretto C, Falda M. Recombinant human soluble tumor necrosis factor receptor fusion protein as treatment for steroid refractory graft-versus-host disease following allogeneic hematopoietic stem cell transplantation. Am J Hematol 2007;82(1):45-52.
8. Fall-Dickson JM, Mitchell SA, Marden S, Ramsay ES, Guadagnini JP, Wu T, St John L, Pavletic SZ; National Institutes of Health Chronic Graft-versus-Host Disease Study Group. Oral symptom intensity, health-related quality of life, and correlative salivary cytokines in adult survivors of hematopoietic stem cell transplantation with oral chronic graft-versus-host disease. Biol Blood Marrow Transplantation 2010;16(7):948-956. Epub 2010 Feb 6.
9. Friedrichs B, Tichelli A, Bacigalupo A, Russell NH, Ruutu T, Shapira MY, Beksac M, Hasenclever D, Socie G, Schmitz N. Long-term outcome and late effects in patients transplanted with mobilised blood or bone marrow: A randomised trial. Lancet Oncol 2010;11(4):331-338. Epub 2010 Jan 30.
10. Wang Y, Xu LP, Liu DH, Chen H, Chen YH, Han W, Liu KY, Huang XJ. First-line therapy for chronic graft-versus-host disease that includes low-dose methotrexate is associated with a high response rate. Biol Blood Marrow Transplantation 2009;15(4):505-511. Epub 2009 Feb 12.
11. Schubert MM, Williams BE, Lloid ME, Donaldson G, Chapko MK. Clinical assessment scale for the rating of oral mucosal changes associated with bone marrow transplantation. Development of an oral mucositis index. Cancer 1992;69(10): 2469-2477.
12. de la Rosa Garcia E, Bologna Molina R, Vega Gonzalez Tde J. Graft-versus-host disease, an eight case report and literature review. Med Oral Patol Oral Cir Bucal 2006;11:E486-E492.
13. Resende RG, Correia-Silva Jde F, de Almeida HC, Vaz RR, Gomez RS. Letter to the editor. Mucoceles. Spec Care Dentist 2010;30(3):127-128.
14. Treister NS, Woo SB, O'Holleran EW, Lehmann LE, Parsons SK, Guinan EC. Oral chronic graft-versus-host disease in pediatric patients after hematopoietic stem cell transplantation. Biol Blood Marrow Transplant 2005;11(9): 721-731.
15. Nagler R, Barness-Hadar L, Lieba M, Nagler A. Salivary antioxidant capacity in graft-versus-host disease. Cancer Invest 2006;24(3):269-277.
16. Pavletic SZ, Martin P, Lee SJ, Mitchell S, Jacobsohn D, Cowen EW, Turner ML, Akpek G, Gilman A, McDonald G, Schubert M, Berger A, Bross P, Chien JW, Couriel D, Dunn JP, Fall-Dickson J, Farrell A, Flowers ME, Greinix H, Hirschfeld S, Gerber L, Kim S, Knobler R, Lachenbruch PA, Miller FW, Mittleman B, Papadopoulos E, Parsons SK, Przepiorka D, Robinson M, Ward M, Reeve B, Rider LG, Shulman H, Schultz KR, Weisdorf D, Vogelsang GB; Response Criteria Working Group. Measuring therapeutic response in chronic graft-versus-host disease: National Institutes of Health Consensus Development Project on Criteria for Clinical Trials in Chronic Graft-Versus-Host Disease: IV. Response to Criteria Working Group Report. Biol Blood Marrow Transplant 2006;12(3):252-266.
17. American Society for Blood and Marrow Transplantation. Chronic GVHD activity assessment—Clinician. Available at: http://asbmt.affiniscape.com/associations/11741/files/ResponseCriteriaAPPENDIXAFormA.pdf. Accessed February 16, 2011.
18. Torres SR, Peixoto CB, Caldas DM, Silva EB, Akiti T, Nucci M, de Uzeda M. Relationship between salivary flow rates and Candida counts in subjects with xerostomia. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002;93(2):149-154.
19. Marton K, Madlena M, Banoczy J, Varga G, Fejerdy P, Sreebny LM, Nagy G. Unstimulated whole saliva flow rate in relation to sicca symptoms in Hungary. Oral Dis 2008;14(5):472-477.
20. Dijkstra PU, Huisman PM, Roodenburg JL. Criteria for trismus in head and neck oncology. Int J Oral Maxillofac Surg 2006;35(4):337-342. Epub 2005 Nov 8.
21. Navazesh M, Kumar SK. Xerostomia: Prevalence, diagnosis, and management. Compend Contin Educ Dent 2009;30(6):326-328, 331-322.
22. Dawes C. Physiological factors affecting salivary flow rate, oral sugar clearance, and the sensation of dry mouth in man. J Dent Res 2006;66 Spec No:648-653.
23. Skert C, Patriarca F, Sperotto A, Cerno M, Fili C, Zaja F, Stocchi R, Geromin A, Damiani D, Fanin R. Sclerodermatous chronic graft-versus-host disease after allogeneic hematopoietic stem cell transplantation: Incidence, predictors and outcome. Haematologica 2006;91(2):258-261.
24. Treister NS, Cook EF Jr, Antin J, Lee SJ, Soiffer R, Woo SB. Clinical evaluation of oral chronic graft-versus-host disease. Biol Blood Marrow Transplant 2008;14(1):110-115.
25. Dijkstra PU, Kalk WW, Roodenburg JL. Trismus in head and neck oncology: A systematic review. Oral Oncol 2004;40(9):879-889.

Exercise No. 294

Special Patient Care

Subject Code 750

The 15 questions for this exercise are based on the article "Oral involvement of chronic graft-versus-host disease in hematopoietic stem cell transplant recipients" on pages 458-462. 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 oral complications of chronic graft-versus-host disease (cGVHD);
- recognize the oral issues related to cGVHD; and
- recognize the prevelance of cGVHD in transplant patients.

1. Oral manifestations of chronic graft-versus-host disease (cGVHD) include all of the following except one. Which is the exception?
   A. Mucosal lesions
   B. Salivary gland dysfunction
   C. Interproximal decay
   D. Cutaneous sclerosis

2. Oral involvement was present in what percentage of patients with cGVHD?
   A. 45.5
   B. 54.5
   C. 68.2
   D. 81.8

3. Oral mucosal lesions of cGVHD are similar to those of
   A. erethema multiforme.
   B. lichen planus.
   C. pemphigus vulgaris.
   D. cicitricial pemphegoid.

4. cGVHD oral lesions can present as all but which of the following?
   A. Atrophic
   B. Hypertrophic
   C. Hyperkeratotic
   D. Erythematous

5. Patients with cGVHD could experience limitation in mouth opening due to
   A. decreased nerve activity.
   B. increased collagen deposition.
   C. muscle atrophy.
   D. TMJ ankylosis.

6. Which type of transplant had the patients in the study received?
   A. Stem cell
   B. Organ
   C. Cornea
   D. Bone

7. What percentage of patients in the study had at least one oral manifestation of cGVHD?
   A. 17.3
   B. 27.0
   C. 81.1
   D. 89.2

8. How many cases of mucositis were identified in the study?
   A. 0
   B. 10
   C. 23
   D. 37

9. How many patients in the study had salivary gland involvement?
   A. 0
   B. 20
   C. 22
   D. 26

10. How many patients in the study had TMJ disorders?
   A. 0
   B. 2
   C. 13
   D. 17

11. A high presence of pain was noticed in which stage of cGVHD?
    A. Early
    B. Late
    C. Middle
    D. Cicatricial

12. In cGVHD, where were lesions most commonly located?
    A. Buccal mucosa
    B. Palatal mucosa
    C. Peritonsillar area
    D. Gingival sulcus

13. All of the following are diagnostic features of cGVHD except one. Which is the exception?
    A. Chronic joint pain
    B. Lichen-type features
    C. Hyperkeratotic plaques
    D. Restriction of mouth opening

14. The NIH considers xerostomia as an oral manifestation of cGVHD. Xerostomia occurs whenever there is salivary disease.
    A. Both statements are true.
    B. The first statement is true; the second is false.
    C. The first statement is false; the second is true.
    D. Both statements are false.

15. Cutaneous sclerosis is a common symptom of cGVHD. Most patients with cutaneous sclerosis report a reduction in mouth opening.
    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.

Instructions are on page 431.
Answer form is on page 512.
Answers for this exercise must be received by October 31, 2012.

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Effects of a paste-free prophylaxis polishing cup and various prophylaxis polishing pastes on tooth enamel and restorative materials

David A. Covey, DDS, MS ▪ Caren Barnes, MS ▪ Hidehiko Watanabe, DDS, MS ▪ William W. Johnson, DDS, MS

The application of cleaning and polishing agents to a patient's dentition is a routine part of many dental practices. This study measured the surface roughness and surface gloss of tooth enamel, composite resin, and dental porcelain restorative materials when exposed to a paste-free prophylaxis polishing cup as well as a conventional prophylaxis polishing paste. Samples of human tooth enamel, a composite resin restorative material, and dental porcelain were prepared by a series of polishing papers to produce a flat smooth surface. The baseline average surface roughness (R_a) was measured using a contact stylus profilometer, and the surface gloss was measured with a glossmeter. The test samples were subjected to a standardized polishing routine using a paste-free prophylaxis polishing cup and a fine- or coarse-particle prophylaxis paste. Post-treatment surface roughness and gloss measurements were compared using a paired *t* statistical test.

The conventional prophylaxis pastes increased surface roughness and decreased the gloss of the composite resin and tooth enamel test groups. The paste-free cups did not significantly affect the surface roughness of the enamel or the restorative materials. Dental porcelain surface roughness essentially was not affected by the application of paste-free cups and the fine and coarse pastes.

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Surface polishing of teeth and dental restorations is an integral part of a wide variety of dental procedures, from the removal of stains and plaque during dental hygiene prophylaxis to the finishing and polishing of dental restorations. As an element of an oral prophylaxis, surface polishing produces smooth surfaces on the teeth and restorations, thereby reducing the adherence of oral accretions such as dental biofilm (plaque) and extrinsic stains.[1] As an element of finishing and polishing dental restorations, surface polishing provides smooth restorative surfaces. Emphasis should be placed on the correct polishing of esthetic restorative materials once the restorations are completed, with the initial finishing and polishing performed by the dentist. From that time on, restorations should be polished only with polishing agents recommended by the material's manufacturer. If that information is not available, the clinician should select a polishing agent that is suitable for that specific material or use an abrasive-free cleaning agent.[2]

Dental prophylaxis agents can be classified as either nonabrasive or abrasive. Nonabrasive cleaning agents do not abrade the surfaces of teeth or restorative materials. Cleaning agents have flat, round particles that still produce a high luster.[1] The most readily available cleaning agent is made of feldspar. Feldspar particles are composed of alkali, a compound of sodium, potassium, and calcium aluminosilicates. This cleaning agent is formulated into a powder and can be mixed with a neutral sodium fluoride solution or water to apply as a paste.

Abrasive prophylaxis polishing agents are available in two basic forms: dry powders, also referred to as *flours*, which must be mixed with a liquid (water, fluoride solution, or mouthrinse), and commercially prepared polishing pastes, which are available in bulk or individual unit doses. Dry powders or flours are graded in order of increasing fineness: F, FF, and FFF.[3] Powders or flours applied to the dentition without wetting agents can create excessive heat. For this reason, the use of dry abrasives or powder on a dry polishing cup is contraindicated due to the potential for thermal injury to natural teeth.[1,4]

The particle grit size of commercially prepared polishing pastes is graded from fine to coarse, based on standard sieves through which the particles pass. The types of abrasive particles used in polishing pastes vary among the commercial varieties and from one grit size to another, yet there is no industry standard to specifically define these terms or determine a consistently sized abrasive particle. The physical properties of an abrasive particle—hardness, size, and shape—are important to the rate of polishing. To be effective, abrasive particles must be harder than the surface or material being polished; additionally, the application method, including pressure and speed, will affect the rate of substrate surface removal.

Commercially prepared prophylaxis polishing pastes combine abrasives with a binder, humectants, a coloring agent, preservatives, and flavoring agents. The types of abrasive particles used in commercial prophylaxis polishing paste include flour of pumice, aluminum oxide (alumina), silicon carbide, aluminum silicate, silicon dioxide, carbide compounds, garnet, feldspar, zirconium silicate, zirconium oxide, boron, and calcium carbonate; other abrasive particles include emery, perlite, and silica.[1,4-6] Collectively, these abrasive agents have a Mohs hardness number of 3.0–9.3.[1,4] Pumice and glycerin are the most commonly used ingredients in commercially prepared polishing pastes.

As of this writing, the U.S. Food and Drug Administration (FDA) does not regulate polishing pastes. The FDA does not recognize or designate any oral prophylaxis paste as containing a drug, and therapeutic additives are recognized by the FDA only as secondary components.[7]

Many clinicians will use a single, coarse grit prophylaxis paste to polish tooth structure and dental restorations during routine hygiene procedures. A survey of published sales indicates that coarse grit is the leading seller of polishing paste; 80% of polishing paste sales are coarse grit and 10% are medium grit.[8] It has been suggested that using the coarsest polishing paste available will remove the heaviest amounts of stain as well as the lightest amounts, thus saving time, hence the preference for coarse grit polishing paste. However, the use of coarse grit polishing paste can cause dentin hypersensitivity, tooth structure wear, and rough tooth and restoration surfaces; it also can accelerate staining and the retention of dental plaque and calculus. Coarse grit paste should be followed by the use of medium grit paste, and the final polish should be done using fine grit paste.[1,4,6,9,10] A new device has been introduced recently that is unique to the polishing armamentarium: a disposable prophylaxis angle with an abrasive-impregnated rubber prophylaxis polishing cup.

The study of the effects of prophylaxis polishing agents typically involves investigating the effects of the polishing agent on tooth enamel and/or various restorative materials; therefore, it was the purpose of this study to investigate the effects of this abrasive-impregnated rubber prophylaxis polishing cup on surface roughness and gloss of two dental restorative materials (dental porcelain and composite resin) and human tooth enamel. For comparative purposes, this study also included an investigation of the effects of two grits of traditional prophylaxis polishing paste on enamel, composite resin, and dental porcelain.

Materials and methods

Composite resin samples were formed in a Dalrin mold that was lubricated with a Teflon aerosol spray. The composite resin material (Filtek Supreme, 3M ESPE) was packed into the mold form, which was 10 mm in diameter and 2.0 mm deep. A glass microscope slide was compressed onto the composite resin to create a smooth, flat surface. The specimens were polymerized for 40 seconds using a curing light (COE Lunarta, GC America Inc.).

Dental porcelain samples were prepared from OPC 3G porcelain shade tabs of amorphous glass overlay porcelain (Pentron Ceramics, Inc.). The disc-shaped porcelain tabs are 1.0 cm in diameter and 2.0 mm thick. The composite resin and porcelain specimens were wet-polished using a series of aluminum carbide grit papers (600, 800, and 1200 grit) to produce a smooth, uniform surface.

Enamel specimens were prepared by removing sections of tooth enamel from extracted human third molars using a water-cooled, slow-speed, diamond rotary saw. The enamel sections were approximately 1.0 cm in diameter and 3.0 mm thick. The enamel surfaces of the specimens were flattened using a series of aluminum carbide grit papers (600, 800, and 1200 grit) mounted on a rotating polishing wheel, resulting in a flat, polished enamel surface at least 5.0 mm in size.

Specimens were stored in distilled water at 37°C prior to testing. A total of 63 experimental specimens were fabricated. Seven disk-shaped samples of the two dental materials and seven human tooth enamel specimens were fabricated for each of the three polishing methods used in this study.

The dental restorative materials and the enamel specimens were exposed to three simulated dental prophylaxis polishing treatments. The polishing treatments utilized were a fine-grit prophylaxis polishing paste (Nupro fine grit, Dentsply International), a coarse-grit prophylaxis polishing paste (Nupro coarse grit, Dentsply International), and an abrasive-impregnated rubber prophylaxis polishing cup (Sunstar Americas, Inc.).

Each specimen was treated with the polishing agent (prophy paste or polishing cup) for 30 seconds at a speed of approximately 900 rpm, using a low-speed dental handpiece. The polishing pastes were applied using a standard, soft-webbed

Chart 1. Surface roughness test results.

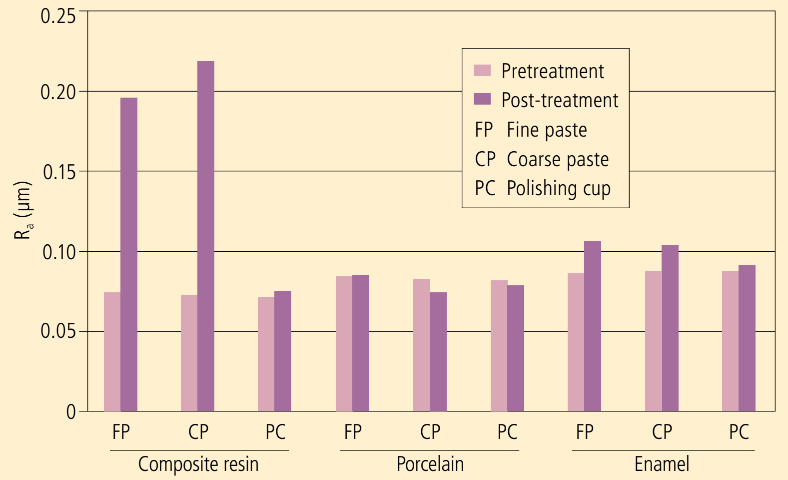
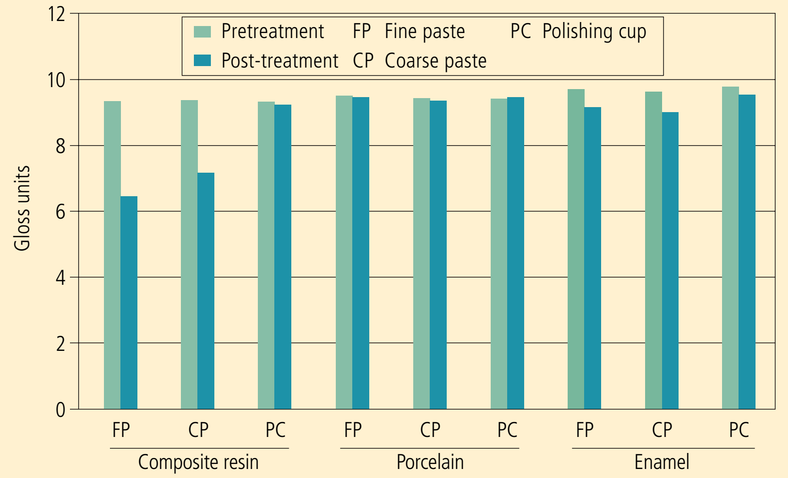


Chart 2. Surface gloss test results.



rubber cup and disposable prophylaxis angle (Young Dental). The samples were cleared of abrasive residue using a distilled water rinse.

The surface roughness and gloss of each specimen were measured prior to and after polishing treatment. The surface roughness profiles of the samples were measured using a contact profilometer (Surfscan SJ-400, Mitutoyo America). A probe tip with a 2.0 µm radius was applied with a force of 0.75 mN along five 0.25 mm sampling lengths, which yielded a total evaluation length of 1.25 mm. The specimen's surface roughness was defined by the arithmetic mean of the magnitude of the deviation of the profile from the mean line measured within the sampling length (R_a). Three measurements were recorded from each specimen, and the average of the R_a values was recorded as the specimen's surface roughness.

The surface gloss of the samples was recorded using a gloss meter (Betagloss Small Area Gloss Meter, Beta Industries) using the DIN 16537 standard. Surface gloss values range from a gloss meter reading of 0.0 (totally diffuse, or matte) to 10.0 (totally specular, or glossy). Three measurements were recorded and averaged for each specimen.

Statistical analysis

The recorded data were used to calculate the mean and standard deviation (SD) for each group. A paired *t*-test with statistical significance set at a P value of 0.05 was used to compare roughness and gloss of the baseline and treated composite resin, dental porcelain, and tooth enamel surfaces. Statistical analysis was done using GraphPad Prism software, version 5.02 (GraphPad Software Inc.).

Results

The mean surface roughness and gloss values for the composite resin, porcelain, and tooth enamel experimental groups obtained before and after the various simulated prophylaxis polishing methods are summarized in Tables 1 and 2 and Charts 1 and 2.

Composite resin surfaces treated with fine or coarse prophylaxis paste exhibited significant increases in surface roughness as measured by R_a values ($P < 0.001$), as well as a decrease in surface gloss ($P < 0.001$, $P < 0.002$). Prophylaxis polishing cup treatment of the composite resin samples did not result in significant changes in surface roughness ($P = 0.167$) or gloss ($P = 0.170$).

The surface roughness of the porcelain samples was not altered by any of the polishing methods. Polishing with coarse prophylaxis paste did affect the porcelain surface gloss ($P = 0.022$). Tooth enamel treated with fine or coarse prophylaxis paste resulted in an increase in surface roughness (P = 0.004, P = 0.026) and a decrease in surface gloss (P = 0.003, P = 0.013). Tooth enamel exposed to the paste-free polishing cup treatment did not exhibit significant changes in surface roughness. However, the surface gloss values of tooth enamel polished with polishing cups were statistically lower than baseline values.

Table 1. Surface roughness for three materials and three polishing methods.

	Mean surface roughness (SD) (in μm)			Paired t-test
Material	Polishing method	Pretreatment	Post-treatment	P value
Composite resin	Fine paste	0.074 (0.003)	0.196 (0.03)	0.001*
	Coarse paste	0.073 (0.008)	0.218 (0.046)	0.001*
	Polishing cup	0.072 (0.003)	0.075 (0.004)	0.167
Porcelain	Fine paste	0.084 (0.003)	0.085 (0.009)	0.700
	Coarse paste	0.082 (0.004)	0.074 (0.005)	0.062
	Polishing cup	0.081 (0.003)	0.078 (0.004)	0.181
Enamel	Fine paste	0.086 (0.006)	0.106 (0.007)	0.004*
	Course paste	0.088 (0.005)	0.104 (0.011)	0.026*
	Polishing cup	0.088 (0.007)	0.092 (0.004)	0.296

*Statistically significant ($p < 0.05$).

Table 2. Surface gloss for three materials and three polishing methods.

	DIN 16537 gloss units (SD)			Paired t-test
Material	Polishing method	Pretreatment	Post-treatment	P value
Composite resin	Fine paste	9.36 (0.096)	6.43 (0.251)	0.001*
	Coarse paste	9.38 (0.103)	7.19 (1.146)	0.002*
	Polishing cup	9.34 (0.062)	9.24 (0.126)	0.170
Porcelain	Fine paste	9.51(0.113)	9.49 (0.061)	0.446
	Coarse paste	9.44 (0.036)	9.33 (0.088)	0.022*
	Polishing cup	9.42 (0.105)	9.47 (0.047)	0.270
Enamel	Fine paste	9.72 (0.078)	9.18 (0.253)	0.003*
	Coarse paste	9.64 (0.101)	9.03 (0.431)	0.013*
	Polishing cup	9.77 (0.061)	9.54 (0.053)	0.001*

*Statistically significant ($p < 0.05$).

Discussion

Composite resin restorations will exhibit the smoothest surface when polymerized while in direct contact with a polyester matrix (Mylar). This surface layer is resin-rich and softer than the underlying composite. Contouring and finishing the restoration to obtain the proper dental anatomy necessitates removal of this surface. Numerous polishing devices, including abrasive compounds bonded to dental burs, elastomeric or rubber polishing devices, and abrasive pastes, are applied to composite resin restorations to establish a smooth, glossy surface. In the present study, the composite resin material was polished in a manner to simulate the surface finish obtained with a series of medium, fine, and superfine aluminum oxide polishing disks.[11,12]

The surface of a composite resin restoration in an oral environment will be exposed to erosive pH solutions found in foods, as well as abrasives contained in dentifrices and prophylaxis pastes; this exposure results in a roughening of the restoration's surface. *In vivo* and *in vitro* studies have found that prophylaxis tooth-cleaning procedures with commercially available abrasive paste will increase the surface roughness and decrease the gloss of polymer-based dental restorative materials.[11-17]

Jefferies and McCabe *et al* describe the process of abrasive wear as the mechanism most responsible for changing the surface of restorative dental material or tooth structure.[5,18] Abrasive wear can occur as a two- or three-body mechanism. In a two-body mode, the abrasive is attached to a polishing applicator, such as a dental bur, disk, or micropolisher, and applied directly to the specimen surface. Three-body wear occurs when unbound particles (such as polishing and prophylaxis paste) are placed in the interface between the specimen surface and the polishing device.

The surface topography of polished composite resin is influenced by the hardness, size, and distribution of the composite resin's filler particles, the composition of the resin matrix, and the hardness and shape of the abrasive polishing agent.[5,15] Previous studies have suggested that a three-body wear mechanism is responsible for the roughening effect found when prophylaxis pastes are applied to composite resin materials.[17,19] When exposed to prophylaxis agents, the surfaces of composite resin dental materials become roughened by abrasive wear due to selective removal of the relatively soft resin matrix; this results in the subsequent exposure of filler particles.[17,20] A four- to six-fold increase in surface roughness, as measured by R_a values, has been observed when prophylaxis paste is applied to conventional and microfilled composite material.[15] Warren *et al* studied the effects of fine, medium, and coarse pumice-particle prophylaxis pastes and a perlite-based prophylaxis paste on a microhybrid composite, a polyacid-modified composite resin, and a resin-modified glass ionomer cement. All types of prophylaxis paste caused increases in surface roughness in all tested materials.[14]

The extent of the surface roughness will depend on the hardness, size, and shape of the abrasive particles and the composition of the organic matrix and filler particles of the composite resin restoration.[5] The prophylaxis paste and cup used in this study contain particles of pumice, a mineral with a Mohs hardness number of 6, whereas composite resins have a Mohs hardness number of approximately 5–7.

In the present study, the application of a coarse particle (74–177 µm) and fine particle (1–45 µm) pumice-based prophylaxis paste onto a nanofilled composite resin resulted in a significant increase in surface roughness. However, the prophylaxis polishing cup embedded with pumice did not cause significant roughening of the composite resin. The prophylaxis polishing cup uses a two-body wear mechanism and functions in a manner similar to polishers used during the fabrication of composite resin restorations. *In vitro* studies have shown that using diamond-embedded rubber/polymer micro-polishers (Po-Go, Dentsply Caulk) can produce surfaces approaching the surface smoothness of composites polymerized against polyester films.[21-23]

To maintain a highly polished, uniform surface, the embedded abrasive polisher particles must have sufficient hardness to abrade filler particles as well as the composite resin matrix. The composite resin used in the present study is composed of 0.6 µm-sized clusters of loosely bound, zirconia-silica nanosized particles combined with nonagglomerated silica nanoparticles (20 µm) in a Bis-GMA matrix.[20,24] Unlike composite materials with larger filler particles, filler particles in the matrix as well as the particles of the nanoclusters are removed individually during exposure to abrasion.[12,20,25] Surface smoothness is maintained, as selective loss of matrix material around large filler particles and their subsequent loss are avoided.

The effect of the prophylaxis polishing cup on other classifications of composite resins is not easily predicted. Previous research has indicated that while composite resin filler particle size is one influencing factor, the polishing system itself consitutes the major factor in determining surface roughness.[26,27] Other studies have reported that a single polishing system can produce different surface roughness values, depending on the classification types of composite resin tested.[28] Lack of similar surface effects has been observed when a single polishing system is applied to a single classification type, such as nanofilled or flowable composite resins.[20,21,29] Additional research is needed to determine the effect prophylaxis polishing cups will have of the surface on polymeric esthetic dental materials.

The visual appearance, such as shade and gloss, of tooth enamel and composite resin restorative materials is affected by the degree of surface roughness. Stanford *et al* found that composite resins that have been polished appear lighter, whiter, and less glossy than composite resins prepared under a polyester film surface.[30] Shade alterations are due predominately to changes in value (lightness), while hue and chroma are not significantly altered.[31-33]

The effect of abrasives on the gloss values of composite resin has been studied previously. *Gloss* is the shiny surface appearance created when reflected light is equal and opposite to the angle of incidence of an illuminating source.[34,35] This specular light is affected by the surface topography of the object. Composite resin formed against polyester strips will exhibit higher gloss levels compared to composite resin materials that have been exposed to finishing and polishing.[31,36-39] Surface imperfections cause scattering of the specular light. Studies have shown that the surface roughness (R_a) of composite resin materials is inversely related to observed gloss. An increase in R_a values results in decreased specular intensity or gloss; this relationship has been described by both linear and nonlinear equations.[35,40-42]

Simulated toothbrushing and generalized three-body wear studies have reported that the composition of the composite resin material influences gloss retention. Nanofilled and microfilled materials maintained higher gloss than microhybrids and hybrids.[24,43] These studies use dentifrices and a slurry of polymethylmethacrylate beads as third-body particles. In the present study, the pumice particles used in prophylaxis paste were harder and larger than abrasives used in wear tests, resulting in a visually dull surface and a decrease of 40% of the original baseline gloss value. The effect of prophylaxis paste on other types of composite resin materials has not been widely studied.

Porcelain restorations can require adjustment during clinical procedures that result in the removal of dental fabricated glazed surfaces. Porcelain restorative materials have Mohs hardness values in the 6–7 range. The use of abrasives with high Mohs values, such as aluminum oxide (9) and diamond (10), can produce surfaces with surface roughness values comparable to that of glazed porcelain. Numerous studies have investigated the effect of two- and three-body polishing methods on porcelain restorative materials. However, few studies have evaluated the effects of oral care cleaning with dentifrices or a periodic-use prophylaxis cleaning paste on porcelain restorations.[44,45] In the present study, the application of pumice-based prophylaxis paste and prophylaxis polishing cups did not result in a significant change in surface roughness. Simulated toothbrushing studies of porcelain have reported similar results.[45]

Increases in surface roughness alter the color and gloss of porcelain restorations in a manner similar to that observed with composite resin restorations.[46,47] In the present study, the application of coarse prophylaxis paste resulted in a statistically significant decrease in the gloss values of the porcelain surface. However, the treated surface represented a 98.8% retention of the baseline value. It is unlikely that the modification in the gloss of the treated surface would be clinically significant. Clinicians find it difficult to subjectively discern minor differences in the surface gloss of highly polished dental restorations.[48]

The main purpose of prophylaxis paste is the removal of soft plaque, deposits, and extrinsic staining from the surface of enamel and dentin. Pumice-based prophylaxis paste is reported to be the most widely used; its popularity is due to its cleaning ability.[4] In the present study, both the fine and coarse grit pastes produced an increase in surface roughness of the highly polished baseline enamel. Similar studies that evaluated the effect of prophylaxis paste and dentifrices on polished enamel have reported an increase in surface roughness; however, the surface structure of "intact" enamel is marked by irregularities, including perikmata furrows, pits, mineral deposits, and scratches.[49,50] Contact profilometer surface roughness values for unpolished human tooth enamel range from 0.85–1.63 µm.[51,52]

Studies of human and bovine enamel reveal that prophylaxis pastes do not result in significant changes in surface roughness when applied to intact enamel.[15,53-55] Other studies have found that the application of prophylaxis paste can result in a reduction of surface irregularities and smoothing of the enamel's surface features.[54-56] *In vivo* microscopy studies reveal that polishing-induced scratches on the enamel surface diminish over time and are resolved approximately three to five weeks after polishing.[57] This smoothing effect could be due to the patient's application of dentifrices during toothbrushing.[57] Similar results are reported when pumice-polished tooth enamel is subjected to simulated toothbrushing *in vitro*.[58]

The prophylaxis paste and prophylaxis polishing cup-induced roughening of the enamel specimens in the present study was sufficient to cause a reduction in gloss; however, gloss retention was still high relative to baseline values. Gloss values for intact unpolished and polished tooth enamel have not been studied.

Conclusion

Under the limitations of this study, the effect of prophylaxis polishing methods on the surface of composite resin, dental ceramic, and tooth enamel was material-dependent. Surface roughness and gloss of composite resin was significantly affected by the application of prophylaxis paste. Dental porcelain surfaces were not significantly altered by prophylaxis paste. Prophylaxis paste caused an increase in surface roughness and a decrease in gloss when applied to tooth enamel. The paste-free prophylaxis polishing cup tested had little, if any, effect on the surface roughness and gloss of composite resin, dental ceramic, or tooth enamel.

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References

1. Barnes CM. The science of polishing. Dimen Dent Hygiene 2009;7(11):18-22.
2. Barnes CM. Polishing esthetic restorative materials. Dimen Dent Hygiene 2010;8(1):24-28.

3. Kramer Industries, Inc. Typical screen analyses of grades—Pumice. Available at www.kramerindustriesonline.com/blasting-media/pumice.htm. Accessed August 31, 2011.
4. Wilkins EM. Clinical practice of the dental hygienist, ed. 10. Philadelphia: Lippincott Williams and Wilkins;2009:727-740.
5. Jefferies SR. Abrasive finishing and polishing in restorative dentistry: A state-of-the-art review. Dent Clin North Am 2007;51(2):379-397.
6. Daniel SJ, Harfst SA, Wilder RS. Mosby's cases, concepts, and competencies, ed. 2. St. Louis: Mosby Elsevier;2008:600-622.
7. U.S. Food and Drug Administration. Jurisdictional update: Dental prophylaxis pastes with drug components. Available at: www.fda.gov/CombinationProducts/JurisdictionalInformation/Jurisdictional Updates/ucm106560.htm. Accessed October 20, 2009.
8. Strategic Data Marketing. Dental products market share study report. Available at: www.sdm-data.com. Accessed October 1, 2009.
9. Barnes CM. Protocol for polishing. Dimen Dent Hygiene 2004;2(6):26-32.
10. Gladwin M, Bagby M. Clinical aspects of dental materials, theory, practice and cases, ed. 2. Philadelphia: Lippincott Williams and Wilkins;2004:203-214.
11. Neme AL, Wagner WC, Pink FE, Fraizer KB. The effect of prophylactic polishing pastes and toothbrushing on the surface roughness of resin composite materials *in vitro*. Oper Dent 2003;28(6):808-815.
12. Ergucu Z, Turkun LS. Surface roughness of novel resin composites polished with one-step systems. Oper Dent 2007;32(2):185-192.
13. Schmidlin PR, Sener B, Lutz F. Cleaning and polishing efficacy of abrasive-bristle brushes and a prophylaxis paste on resin composite material *in vitro*. Quintessence Int 2002;33(9):691-699.
14. Warren DP, Colescott TD, Henson HA, Powers JM. Effects of four prophylaxis pastes on surface roughness of a composite, a hybrid ionomer, and a compomer restorative material. J Esthet Restor Dent 2002;14(4):245-251.
15. Roulet JF, Roulet-Mehrens TK. The surface roughness of restorative materials and dental tissues after polishing with prophylaxis and polishing pastes. J Periodontol 1982;53(4):257-266.
16. Wu SS, Yap AU, Chelvan S, Tan ES. Effect of prophylaxis regimens on surface roughness of glass ionomer cements. Oper Dent 2005;30(2):180-184.
17. Yap AU, Wu SS, Chelvan S, Tan ES. Effect of hygiene maintenance procedures on surface roughness of composite restoratives. Oper Dent 2005;30(1):99-104.
18. McCabe JF, Molyvda S, Rolland SL, Rusby S, Carrick TE. Two- and three-body wear of dental restorative materials. Int Dent J 2002;52(5):406-416.
19. Neme AL, Frazier KB, Roeder LB, Debner TL. Effect of prophylactic polishing protocols on the surface roughness of esthetic restorative materials. Oper Dent 2002;27(1):50-58.
20. Janus J, Fauxpoint G, Arntz Y, Pelletier H, Etienne O. Surface roughness and morphology of three nanocomposites after two different polishing treatments by a multitechnique approach. Dent Mater 2010;26(5):416-425. Epub 2010 Jan 25.
21. Ozel E, Korkmaz Y, Attar N, Karabulut E. Effect of one-step polishing systems on surface roughness of different flowable restorative materials. Dent Mater J 2008;27(6):755-764.
22. Turkun L, Turkun M. The effect of one-step polishing system on the surface roughness of three esthetic resin composite materials. Oper Dent 2004;29(2):203-211.
23. Korkmaz Y, Ozel E, Attar N, Aksoy G. The influence of one-step polishing systems on the surface roughness and microhardness of nanocomposites. Oper Dent 2008:33(1):44-50.
24. Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. J Am Dent Assoc 2003;134(10):1382-1390.
25. Ergucu Z, Turkun LS, Aladag A. Color stability of nanocomposites polished with one-step systems. Oper Dent 2008;33(4):413-420.
26. Lu H, Roeder L, Powers JM. Effect of polishing systems on the surface roughness of microhybrid composites. J Esthet Restor Dent 2003;15(5):297-304.
27. Setcos JC, Tarim B, Suzuki S. Surface finish produced on resin composites by new polishing system. Quintessence Int 1999;30(3):169-173.
28. Yap AUJ, Yap SH, Teo CK, Ng JJ. Comparison of surface finish of new aesthetic restorative materials. Oper Dent 2004;29(1):100-104.
29. Jung M, Eichelberger K, Klimek J. Surface geometry of four nanofiller and one hybrid composite after one-step and multiple-step polishing. Oper Dent 2007;32(4):347-355.
30. Stanford WB, Fan PL, Wozniak WT, Stanford JW. Effect of finishing on color and gloss of composites with different fillers. J Am Dent Assoc 1985;110(2):211-213.
31. Lee YK, Lim BS, Kim CW. Effect of surface conditions on the color of dental resin composites. J Biomed Mater Res 2002;63(5):657-663.
32. Choi MS, Lee YK, Lim BS, Rhee SH, Yang HC. Changes in surface characteristics of dental resin composites after polishing. J Mater Sci Mater Med 2005;16(4):347-353.
33. Chung KH. Effects of finishing and polishing procedures on the surface texture of resin composites. Dent Mater 1994;10(5):325-330.
34. Smith KB. Measuring the perception of glossy surfaces. Pigment Resin Tech 1999;28(4):217-222.
35. O'Brien WJ, Johnston WM, Fanian F, Lambert S. The surface roughness and gloss of composites. J Dent Res 1984;63(5):685-688.
36. Kameyama A, Nakazawa T, Haruyama A, Haruyama C, Hosaka M, Hirai Y. Influence of finishing/polishing procedures on the surface texture of two resin composites. Open Dent J 2008;2:56-60. Epub 2008 Mar 12.
37. Silikas N, Kavvadia K, Eliades G, Watts D. Surface characterization of modern resin composites: a multi-technique approach. Am J Dent 2005;18(2):95-100.
38. Paravina RD, Roeder L, Lu H, Vogel K, Powers JM. Effect of finishing and polishing procedures on surface roughness, gloss and color of resin-based composites. Am J Dent 2004;17(4):262-266.
39. Da Costa J, Ferracane J, Paravina RD, Mazur RF, Roeder L. The effect of different polishing systems on surface roughness and gloss of various resin composites. J Esthet Restor Dent 2007;19(4):214-226.
40. Heintze SD, Forjanic M, Rousson V. Surface roughness and gloss of dental materials as a function of force and polishing time *in vitro*. Dent Mater 2006;22(2):146-165. Epub 2005 Aug 9.
41. Lu H, Roeder L, Lei L, Powers JM. Effect of surface roughness on stain resistance of dental resin composites. J Esther Restor Dent 2005;17(2):102-109.
42. Ferracane J, Khajotia S, Smart K, Ferracane L. Correlating surface gloss and roughness for abraded commercial composites. Dent Mater 2009;25(5):e19.
43. Lee YK, Lu H, Oguri M, Powers JM. Changes in gloss after generalized wear of composite resins. J Prosthet Dent 2005;94(4):370-376.
44. Bollen CM, Lambrechts P, Quirynen M. Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: A review of the literature. Dent Mater 1997;13(4):258-269.
45. Heintze S, Forjanic M, Ohmiti K, Rousson V. Surface deterioration of dental materials after simulated toothbrushing in relation to brushing time and load. Dent Mat 2010;26(4):306-319.
46. Sarac D, Sarac S, Kulunk S, Ural C, Kulunk T. The effect of polishing techniques on the surface roughness and color change of composite resins. J Prosthet Dent 2006;96(1):33-40.
47. Obregon A, Goodkind RJ, Schwabacher WB. Effects of opaque and porcelain surface texture on the color of ceramometal restorations. J Prosthet Dent 1981;46(3):330-340.
48. Barucci-Pfister N, Gohring TN. Subjective and objective perceptions of specular gloss and surface roughness of esthetic resin composites before and after artificial aging. Am J Dent 2009;22(2):102-110.
49. Lutz F, Sener B, Imfeld T, Barbakow F, Schupbach P. Comparison of the efficacy of prophylaxis pastes with conventional abrasives or a new self-adjusting abrasive. Quintessence Int 1993;24(3):193-201.
50. Worschech CC, Rodrigues JA, Martins LR, Ambrosano GM. *In vitro* evaluation of human dental enamel surface roughened bleached with 35% carbamide peroxide and submitted to abrasive dentifrice brushing. Pesqui Odontol Bras 2003;17(4):342-348.
51. Mathias J, Kavitha S, Mahalaxmi S. A comparison of surface roughness after microabrasion of enamel with and without using CPP-ACP: An *in vitro* study. J Conserv Dent 2009;12(1):22-25.
52. Cobankara FK, Unlu N, Altinoz HC, Ozer F. Effect of home bleaching agents on the roughness and surface morphology of human enamel and dentine. Int Dent J 2004;54(4):211-218.

53. Castanho GM. Arana-Chavez VE, Fava M. Roughness of human enamel surface submitted to different prophylaxis methods. J Clin Pediatr Dent 2008;32(4):299-304.
54. Salami D, Luz MA. Effect of prophylactic treatments on the superficial roughness of dental tissues and two esthetic restorative materials. Pesqui Odontol Bras 2003;17(1):63-68. Epub 2003 Aug 5.
55. Gerbo LR, Lacefield WR, Barnes CM, Russell CM. Enamel roughness after air-powder polishing. Am J Dent 1993;6(2):96-98.
56. Winston AE, Charig A, Patel V, McHale WA, Malerman R. Effect of prophy pastes on surface of tooth enamel. Abstract No. 0966. IADR/AADR/CADR 83rd General Session, Baltimore;2005.
57. Christensen RP, Bangerter VW. Immediate and long-term *in vivo* effects of polishing on enamel and dentin. J Prosthet Dent 1987;57(2):150-160.
58. Heintze SD, Forjanic M. Surface roughness of different dental materials before and after simulated toothbrushing *in vitro*. Oper Dent 2005; 30(5):617-626.

Manufacturers

Beta Industries, Carlstadt, NJ
800.272.7336, www.betascreen.com

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800.532.2855, www.caulk.com

Dentsply International, York, PA
800.877.0020, www.dentsply.com

GC America Inc., Alsip, IL
800.323.7063, www.gcamerica.com

GraphPad Software Inc., La Jolla, CA
858.454.5577, www.graphpad.com

Mitutoyo America, Aurora, IL
888.648.8869, www.mitutoyo.com

Pentron Ceramics, Inc., Somerset, NJ
800.496.9500, www.pentronceramics.com

Sunstar Americas, Inc., Chicago, IL
888.777.3101, www.gumbrand.com

Young Dental, Earth City, MO
800.325.1881, www.youngdental.com

3M ESPE, St. Paul, MN
800.634.2249, solutions.3m.com

Exercise No. 295

Dental Materials

Subject Code 017

The 15 questions for this exercise are based on the article "Effects of a paste-free prophylaxis polishing cup and various prophylaxis polishing pastes on tooth enamel and restorative materials" on pages 466-473. This exercise was developed by Daniel S. Geare, DMD, in association with the *General Dentistry* Self-Instruction committee.

Reading the article and successfully completing the exercises will enable you to:

- understand the composition of different types of prophylaxis pastes;
- understand how the composition of prophylaxis pastes affect the surfaces of enamel and restorations; and
- understand the effects of the abrasive-impregnated rubber prophylaxis polishing cup.

1. Surface polishing of teeth and dental restorations accomplishes all but which of the following?
   A. Removal of stains
   B. Finishing of dental restorations
   C. Weakening the enamel
   D. Creating smooth surfaces

2. Most dental cleaning agents contain
   A. feldspar.
   B. diatomaceous earth.
   C. bismuth.
   D. baking soda.

3. Two types of polishing agents are dry powders and commercially prepared polishing pastes. Higher abrasiveness of polishing pastes can result in greater risk of overheating the tooth.
   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. To be effective, abrasive particles must be __________ than the surface or material being polished.
   A. softer
   B. wetter
   C. harder
   D. smoother

5. The ingredients of prophylaxis paste include all but which of the following?
   A. Binder
   B. Preservatives
   C. Wetting agent
   D. Chelating agent

6. Abrasive particles included in prophylaxis paste include all but which of the following?
   A. Aluminum oxide
   B. Calcium carbonate
   C. Ferric oxide
   D. Zirconium silicate

7. The use of prophylaxis paste can actually increase staining and plaque retention. For this reason, final polishing should be done with fine grit paste.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

8. Prophylaxis polishing can increase the surface roughness on all but which of the following surfaces?
   A. Composite resin
   B. Porcelain
   C. Enamel
   D. Root surfaces

9. How much does the surface roughness of conventional and microfilled composite increase when polished with prophylaxis paste?
   A. Seven to nine times
   B. Four to six times
   C. Two to three times
   D. Zero to one times

10. Which of the following particle sizes (in µm) would be considered coarse?
    A. 1–43
    B. 35–63
    C. 74–123
    D. 190–193

11. **Shade alterations due to polishing primarily affect**
   A. value.
   B. hue.
   C. chroma.
   D. saturation.

12. **Which materials have the highest specular intensity?**
   A. Nanofilled
   B. Microhybrid
   C. Hybrids
   D. Glass ionomer

13. **Surface roughness is increased with coarse or fine grit prophylaxis paste on highly polished intact enamel. Application of prophylaxis paste can reduce surface irregularities of enamel surfaces.**
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

14. **What is the primary purpose of prophylaxis paste?**
   A. Remove plaque and stain
   B. Polish smooth surfaces
   C. Deliver extrinsic fluoride
   D. Improve cleansability

15. **Prophylaxis paste caused an increase in surface roughness. The paste-free prophylaxis polishing cup had a similar effect.**
   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.

Instructions are on page 431.
Answer form is on page 512.
Answers for this exercise must be received by October 31, 2012.

self CDE 2 HOURS CREDIT instruction

Correlation of awareness and practice of working postures with prevalence of musculoskeletal disorders among dental professionals

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Over the last 20 years, a great many innovations have been introduced that are designed to reduce laborious activities; however, an unexpected consequence of these developments is a trend toward a sedentary lifestyle and prolonged static postures that are accompanied by musculoskeletal disorders (MSDs). MSDs have become a major issue of concern because the afflictions can be severe enough to disable professional careers. Although clinical dentistry is a field with immense potential for MSDs, only a few studies have investigated this issue.

The present study was carried out addressing prevalence and awareness level of MSDs among 500 dental professionals from Central India. Also, the interrelationship between practices of working postures with occurrence of pain in different body parts were assessed using a structured questionnaire format. The results were statistically significant, and indicated that the prevalence of MSDs is high and that there is a dire need to enhance awareness regarding correct working postures. This study encompassed all factors that can be addressed as causes for MSDs among dentists.

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Dentistry is a specialized field in which dentists work long hours in a seated, static position. The practice of dentistry requires repetitive motions of the fingers and wrists as well as prolonged awkward postures. Precise motor skills with intense hand-eye coordination are required to perform routine dental procedures like cavity preparation, restorations, scaling, and extractions. Lack of knowledge regarding the proper working posture in addition to busy clinical schedules, time constraints, and unexpected procedural challenges can cause stress. Clinicians often neglect proper posture and ergonomics during dental procedures, leading to musculoskeletal pain. While the occasional backache or neckache is not cause for alarm, if regularly occurring pain or discomfort is ignored, the cumulative physiological damage can lead to an injury or even a career-ending disability.

A number of investigations have suggested a causal link between the ergonomics of dental care delivery and numerous musculoskeletal problems.[1-6] Studies reveal that dentists experience more neck, shoulder, and back pain than practitioners in other occupations.[7,8] Though these studies have noted the prevalence of musculoskeletal disorders (MSDs) in dentistry, there are no reports that analyze dental practioners' awareness levels of the postures involved in delivering dental procedures. Further, no existing reports have used a structured questionnaire format to address the interrelationship between practices of working postures with the presence of pain in different body parts.

The aims of the current study were to assess the prevalence and distribution of neck, back, shoulder, and wrist problems among dentists; analyze the awareness level of practitioners regarding the correctness of various postures involved in carrying out dental procedures; and estimate whether any correlation exists between correct/incorrect posture and the occurrence of MSDs. Neck, back, shoulder, and wrist pain was specifically targeted in this study because they are involved most closely with the postures required to carry out dental procedures.

Materials and methods

Study population

A cross-sectional study was designed wherein 500 dentists were selected randomly from a list of members of the Indian Dental Association (IDA) in the state of Madhya Pradesh. Participants were provided with a questionnaire and feedback was collected. At least three years of clinical work experience was the sole requirement to participate in the study.

Study design and data collection

The first question in the questionnaire asked whether the subject had suffered from pain in the shoulder, back, neck, or wrist. Questions 2–11 focused on the sitting postures employed by clinicians to carry out their work and their awareness of the correct position of the shoulders, back, neck, upper arm, and forearm; maintainance of a neutral position; positioning of the patient in relation to the operator; instrument carriage; glove selection; and any hand exercises performed by the clinician after each procedure (Fig. 1). Prior to distribution, the questionnaire was tested for comprehensibility and relevance among 20 dentists. The document was distributed by the authors to each participant between December 2009 and March 2010.

Practitioners were allowed to select more than one option, as some questions allowed for more than one answer. However, if a subject selected an option for one question but did not select the same option for a similar question, this was considered as a wrong response in the statistical analysis, suggesting that the practitioner was not completely aware of the objectives. The questionnaire included the respondent's name (optional), qualifications, clinical experience, age, gender, level of education, duration of employment, general health status, and occurrence of musculoskeletal complaints. The next step in the study was to provide the right answers to each question with suitable explanations for their future reference, with the aim of helping the clinician to correct his or her ergonomics. The authors also spent time with each participant, making him or her aware of the proper ergonomic postures while working on patients.

Results and observations

A total of 500 dentists were evaluated for musculoskeletal pain. Dentists included in the study population were residents of the major cities of Madhya Pradesh, including Bhopal, Indore, Gwalior, and Jabalpur. The sample consisted of 338 male and 162 female dentists; 308 of the participants (61%) were general dentists and 192 were specialists, including orthodontists, oral and maxillofacial surgeons, endodontists, periodontists, prosthodontists, and

1. Have you suffered from any of the following symptoms?	a. Pain in the shoulders b. Pain in the back c. Pain in the neck d. Pain in the wrist
2. Posture of neck	a. Head tilt 0–15 degrees b. Head tilt 0–30 degrees c. As comfortable to reach treatment area
3. Posture of back	a. Adjusted according to the reach b. Trunk flexion of 0–20 degrees (bending of spine) c. Trunk flexion of 0–40 degrees
4. Position of shoulders	a. Shoulders hunched forward b. Shoulders lifted toward ear c. Shoulder in horizontal line
5. Upper arm position	a. Elbows held above waist level b. More than 20 degrees of elbow abduction c. Elbows at waist level, held slightly away from body
6. Forearm position	a. Raised or lowered by pivoting elbow joint b. Parallel to the floor c. Raised or lowered without pivoting elbow joint
7. Maintain neutral position?	a. Yes b. No c. Adjusted according to the need
8. Holding of instruments	a. C-shaped (index finger and thumb form a "C") b. U-shaped (index finger and thumb are curved inward toward the handle) c. Grasp that allows finger pads to contact the handle and allows for precise control of the instrument
9. Gloves used	a. Loose fit across palm and wrist b. Gloves that fit across the palm and wrist c. The index finger of the opposite hand slips easily under the wrist area of the gloved hand
10. Preferred hand exercise after procedure	a. Full grip (flexor muscle) b. Finger extension (extensor muscle) c. Putting the hand in ice for relaxation d. All fingers spread (extensor and abductor muscles)
11. Position of the patient in relation to the operator	a. Patient's open mouth below the point of the operator's elbow b. Patient's open mouth above the point of the operator's elbow c. Patient's open mouth at the point of the operator's elbow

Fig. 1. Questionnaire form.

Table 1. Prevalence of MSDs affecting dental professionals.

Location of pain	No. of dentists suffering from pain (percentage)
Neck	160 (32)
Back	159 (32)
Shoulder	104 (21)
Wrist	31 (6)
None	46 (9)
Total	500 (100)

Table 2. Correct/incorrect postures practiced by respondent dentists.

Ergonomic posture	Correct practice (percentage)	Incorrect practice (percentage)
Neutral position	129 (26)	371 (74)
Upper arm position	136 (27)	364 (73)
Gloves used	181 (36)	319 (64)
Position of the patient in relation to the operator	187 (37)	313 (63)
Neck posture	190 (38)	310 (62)
Preferred hand exercise after procedure	205 (41)	295 (59)
Back posture	206 (41)	294 (59)
Forearm position	268 (54)	232 (46)
Shoulder posture	370 (74)	130 (26)
Instrument hold	387 (77)	113 (23)

Table 3. Number of respondents reporting no pain.

No pain reported	Question	Correct practice (percentage)	Incorrect practice (percentage)
46 (9%)	Instrument hold	46 (100)	0
	Neutral position	45 (98)	1 (2)
	Gloves used	44 (96)	2 (4)
	Forearm position	42 (91)	4 (9)
	Position of the patient in relation to the operator	39 (85)	7 (15)
	Shoulder posture	38 (83)	8 (17)
	Upper arm position	34 (74)	12 (26)
	Back posture	32 (70)	14 (30)
	Neck posture	30 (65)	16 (35)
	Preferred hand exercise after procedure	19 (41)	27 (59)

pediatric dentists. A total of 149 subjects had less than five years of experience, 257 had 5–10 years of experience, and 94 had more than 10 years of experience. On average, the dentists worked approximately 40 hours per week.

Data were sorted based on the noted presence or absence of neck, back, shoulder, and wrist pain (Tables 1–3). Further, correct or incorrect postures that corresponded to specific problems were tabulated (Tables 4–7). Right answers were taken for correct practice of postures and wrong answers for improper practice. The tables were statistically analyzed using SPSS software package, version 10.

Prevalence and distribution of MSDs

As observed in Table 1, 454 of 500 dentists (91%) suffered from one or more MSDs. Back and neck pain had the highest incidence (32% each), followed by shoulder pain (21%). Wrist pain showed the lowest incidence (6%).

Awareness/practice of ergonomic postures

Table 2 represents the level of awareness of various ergonomic postures among study participants. It is evident that more than 50% of the dentists did not practice most of the ergonomic postures in a correct way (shown as incorrect practice of postures), implying a poor level of awareness.

An interesting analysis in this study was the evaluation of the ergonomic postures of subjects who indicated no pain. Table 3 represents the level of awareness among dentists who did not suffer from any MSDs. More than 65% of these dentists practiced most of the postures in a correct way, indicating a significantly higher degree of awareness. Yet more than 50% of these subjects were unaware of the preferred hand exercises to be performed following dental procedures.

Correlation of correct/incorrect working postures with symptoms

Data were sorted based on the presence or absence of four key types of MSDs: neck, back, shoulder, and wrist issues.

Neck

Of 160 dentists who suffered neck pain, 102 were found to be practicing with their neck positioned incorrectly (chi-square = 11.097 with 1 degree of freedom); 97 did not maintain a neutral position (chi-square = 46.626 with 1 degree of freedom); and 122 did not practice correct operator position in relation to the patient (chi-square = 54.280 with 1 degree of freedom) (Table 4). The incorrect posture practices had a significant correlation to neck pain ($P < 0.0001$). It also was observed that a significant number of the 46 dentists who did not suffer neck pain exhibited proper knowledge of the aforementioned postures.

Back

Of 159 dentists who indicated a concern with their back, 112 positioned their back improperly (chi-square = 22.448 with 1 degree of freedom); 97 did not maintain a neutral position (chi-square = 47.162 with 1 degree of freedom); and 122 did not follow correct operator position in relation to the patient (chi-square = 50.622 with 1 degree of freedom) (Table 5). The incorrect practice of postures had a significant correlation with back pain ($P = 0.0001$). A significant number of the 46 dentists who did not suffer back pain exhibited correct knowledge of the aforementioned postures.

Shoulder

Of 104 dentists who suffered shoulder pain, 72 did not practice correct positioning of the upper arm (chi-square = 22.374 with 1 degree of freedom) (Table 6). The incorrect posture practice had a significant correlation with shoulder pain ($P = 0.0001$). However, incorrect positioning of the shoulders (noted in 36 of 104 dentists who suffered shoulder pain) indicated no correlation with shoulder pain (chi-square = 3.771 with 1 degree of freedom) (Table 6) and no statistical significance was observed ($P = 0.052$). Correct positioning of the upper arm and

Table 4. MSDs affecting dental professionals for neck pain (chi-square test).

Ergonomic posture	Presence of neck pain	Total	Correct practice	Incorrect practice	p value
Neck position	Yes	160	58	102	0.0001*
	No	46	30	16	
Maintenance of neutral position	Yes	160	63	97	0.0001*
	No	46	45	1	
Position of patient in relation to operator	Yes	160	38	122	0.0001*
	No	46	39	7	

*Statistically significant.

Table 5. MSDs affecting dental professionals for back pain (chi-square test).

Ergonomic posture	Presence of back pain	Total	Correct practice	Incorrect practice	p value
Back position	Yes	159	47	112	0.0001*
	No	46	32	14	
Maintenance of neutral position	Yes	159	62	97	0.0001*
	No	46	45	1	
Position of patient in relation to operator	Yes	159	37	122	0.0001*
	No	46	39	7	

*Statistically significant.

Table 6. MSDs affecting dental professionals for shoulder pain (chi-square test).

Ergonomic posture	Presence of shoulder pain	Total	Correct practice	Incorrect practice	p value
Upper arm position	Yes	104	32	72	0.0001*
	No	46	34	12	
Shoulder position	Yes	104	68	36	0.052*
	No	46	38	8	

*Statistically significant.

Table 7. MSDs affecting dental professionals for wrist pain (chi-square test).

Ergonomic posture	Presence of wrist pain	Total	Correct practice	Incorrect practice	*p* value
Gloves used	Yes	31	9	22	0.001*
	No	46	44	2	
Preference of hand exercise	Yes	31	3	28	0.006
	No	46	19	27	
Forearm position	Yes	31	20	11	0.009*
	No	46	42	4	
Holding instruments	Yes	31	25	6	0.007*
	No	46	46	0	

*Statistically significant.

shoulder correlated with a non-prevalence of pain (Table 6) that was statistically significant.

Wrist

Donning gloves incorrectly showed a significant correlation ($P = 0.0001$) with presence of wrist pain (chi-square = 35.260 with 1 degree of freedom) (Table 7). Performing hand exercises following dental procedures showed no correlation with the presence or absence of wrist pain (chi-square = 7.593 with 1 degree of freedom) (Table 7), and statistical significance was not achieved ($P = 0.006$).

Positioning the forearm correctly showed a correlation with the presence or absence of wrist pain (chi-square = 6.851 with 1 degree of freedom) (Table 7); there also was statistical significance ($P = 0.009$). Further, the method of holding instruments was interrelated with the presence or absence of wrist pain (chi-square = 7.150 with 1 degree of freedom) (Table 7), and statistical significance was observed ($P = 0.007$).

Discussion

Not only have recent technological advancements made life easier, they also have reduced laborious efforts, both on domestic and professional fronts. As a result of reduced physical movements and prolonged static postures (PSPs), the present generation has succumbed to MSDs, which has led to the development of ergonomic science. Dental professionals are, in fact, at a higher risk for MSDs given the great amount of time spent in PSPs during dental procedures. Although the evolution from standing to sitting dentistry has changed the pattern of MSDs, it has not eradicated them.[9] Some studies have reported back, neck, and shoulder pain among dentists despite the use of ergonomic equipment.[10-12]

The present survey represents an effort to evaluate the prevalence of MSDs and level of awareness among dentists regarding ergonomic postures, and to correlate postures to specific body pain. The rate of occurrence of one or more MSDs among participants was alarmingly high (91%). A similar study by Rising *et al* reported a higher prevalence of body pain (71%) among dentists; the authors find this statistic to be highly significant and believe that it warrants the urgent need for precautionary measures.[13] Earlier surveys have also reported a similar degree of prevalence of MSDs.[9,14]

Back and neck pain appear to be the most prevalent; this finding reflects the results of other, similar studies.[6,15-17] Relatively speaking, shoulder pain was less prevalent, at 21% of respondents, compared to wrist pain (6%). In contrast, Milerad and Ekenvall reported a higher incidence of shoulder pain (51%).[18] A 1997 survey by the American Dental Association reported that 9.2% of dentists had been diagnosed by a physician as having an upper extremity MSD; of this group, 20% required surgery and more than 40% had to reduce their workload.[19] Certain studies have established specific correlations between age/gender and MSDs.[13,20] The present study could find no correlation between prevalence of MSDs and individual characteristics of the respondents, such as age, gender, qualification, duration of clinical practice, and general health status.

In the present study, fewer than 50% of the respondents indicated awareness regarding ergonomic postures, implying that less than half of dentists lack this awareness. Interestingly, among dentists who did not suffer any MSDs, more than 70% exhibited a greater awareness level regarding ergonomic postures. It also can be noted that both groups exhibited high degrees of awareness with respect to proper methods of instrument usage and carriage, regardless of whether they suffered from MSDs. This could be attributed to the fact that the method of holding an instrument is emphasized more during dentistry training. However, the possibility of MSDs in the case of a lack of awareness cannot be ruled out. Thus, it can be concluded that the lack of awareness of ergonomic postures could be a contributory factor for MSDs. At the time the present study was conducted, no other reports were available comparing awareness levels with the occurrence of MSDs among dentists.

Musculoskeletal pain has been attributed to various risk factors, including PSPs, repetitive movements, suboptimal lighting, poor positioning, genetic predisposition, mental stress, physical conditioning, and age.[9] Seated hygienists and periodontists are predisposed to neck, shoulder, and wrist pain largely due to PSPs combined with forceful, repetitive movements inherent to the job. On the other hand, general practitioners tend to be more susceptible to lower back and neck injuries.[9] Even with the best ergonomic equipment, operators find themselves in sustained awkward postures, which consist of forward bending and repeated rotation of the head, neck, and trunk to one side. Also, continuous work in front of and below the operator's eye level can lead to a forward-leaning head and rounded shoulder posture. Over the course of time, imbalances develop between the muscles that stabilize and those that move, and the overworked muscles suffer ischemia that can present as clinical manifestations of pain.

Neck

There have been reports correlating improper positioning of the patient in relation to the operator, neck position, and maintenance of neutral position as contributory factors to neck pain.[14,21] The present survey also witnessed a statistically significant correlation between improper posture assumptions and the presence of neck pain. It has been reported that most dentists and hygienists operate with a forward head posture of at least 30 degrees for 85% of their time in the operatory.[22] The prevalence of neck pain among dentists hovers at approximately 70%.[23]

Back

Improper positioning of the patient in relation to the operator, back position, and neutral position maintenance have been found to contribute to back pain.[14,21,24,25] The present survey also reported a statistically strong correlation between incorrect practices of aforementioned postures and the prevalence of back pain. These findings are supported by similar studies.[6,15] Maintenance of a neutral position implies that the operator sits with his or her forearm and thighs parallel to the floor, back erect, and the hip at a 90 degree angle, while adjusting the chair height to allow his or her heels to rest completely on the floor. Neutral position is the ideal positioning of the body while performing work activities; it is associated with a decreased risk of musculoskeletal injury. It is believed that the more a joint deviates from the neutral position, the greater the risk of injury.[24]

The first component in avoiding fatigue and injury is proper positioning of the patient in relation to the seated clinician. While working, the clinician must be able to gain access to the patient's mouth and the dental unit without excessive bending or stretching or holding his or her elbows above waist level.[24] To achieve this ergonomic posture, the patient's open mouth should be positioned below the point of the operator's elbow. The operator's head should be tilted from 0–15 degrees (the line from eyes to the treatment area is vertical); this complies with the ideal posture of neck and trunk flexion from 0–20 degrees (bending of spine) and creates the ideal posture for the back.[24] MSDs often are the direct result of failure by dentists to maintain these postures in their daily work. Unsurprisingly, research indicates that more than 80% of dental professionals complain of pain in their upper body and back.[21]

Shoulder

Incorrect positioning of the shoulder and upper arm has been determined to be a causative factor of shoulder pain.[24,25] Incorrect positioning of the upper arm results from holding the elbow above waist level; this leads to holding the upper arm away from the body, resulting in fatigue and painful inflammation of the muscle tendons in the shoulder region, clinically termed *rotator cuff tendonitis* (symptoms include severe pain and impaired function of the shoulder joint).[24] Hunching the shoulders forward or lifting them toward the ear are improper positions; keeping the shoulders up or elbows out and/or elevated during all-day treatment of patients will eventually contribute to damaging shoulder and neck strain. Clinicians generally focus on patient needs, ignoring the signals from their own bodies. Keeping the shoulders in a horizontal line implies proper shoulder positioning, while holding the elbows at waist level, slightly away from the body, implies proper upper arm positioning.

The present survey reported a statistically strong correlation between improper upper arm positioning and the prevalence of shoulder pain, but failed to exhibit a similar positive correlation between improper shoulder positions and shoulder pain. However, there is still a link (albeit a weakly positive one) between the knowledge of proper positioning and the absence of pain (Table 6). A study by Alexopoulos *et al* arrived at similar conclusions, that strenuous shoulder and hand movements contribute to shoulder pain.[2]

Wrist

Repetitive forceful pinching or gripping, a sustained non-neutral position, use of vibrating tools, and an improper method of donning gloves are risk factors for the development of wrist tendonitis and carpal tunnel syndrome.[26-29] *Carpal tunnel syndrome* is a form of peripheral neuropathy resulting from compression or vascular insufficiency of the median nerve at the carpal tunnel of the wrist. Possible causes include cumulative trauma, overuse injury, physiologic disorders, or structural changes. In dentistry, it can result from flexion or overextension of the wrist (symptoms include pain, numbness, or a "pins and needles" sensation in the thumb, index, and middle fingers and on the radial side of the hand and/or wrist).

Forearm position plays a significant role in wrist pain.[25] Bending the hand up, down, or from side to side at the wrist as well as holding the smallest finger one full span away from the hand (as is almost always the case in instrumentation) leads to ulnar nerve entrapment (symptoms include numbness, tingling, and/or loss of strength in the lower arm or wrist).[23] Holding the lower arm consistently away from the body (as is done when using ultrasonic scalers, micromotor/airotor handpieces, and photocuring guns) causes compression of the median nerve between the two heads of the pronator teres muscle, leading to the clinical entity termed *pronator syndrome* (symptoms are similar to those of carpal tunnel syndrome).[24]

The correct forearm position entails maintaining the forearm parallel to the floor and raising and lowering the forearm (as needed) by pivoting the elbow joint. The wrist should be straight and in the same horizontal plane as the forearm. Further, holding instruments correctly (using a modified pen grasp or a palm and thumb grasp) is supposed to prevent wrist pain.[30] The present survey could not determine the damaging effects of improper forearm positioning and inappropriate instrument holding on the wrist, yet knowledge of proper postures and an absence of corresponding pain were found to be statistically significant (Table 7).

Proper glove fit is important to avoid muscle strain during instrumentation. Surgical glove-induced injury is a type of MSD caused by improperly fitting gloves (symptoms include tingling, numbness, or pain in the wrist, hand, and/or fingers).[29] This disorder is caused by wearing gloves that are too tight or by wearing ambidextrous gloves. Gloves that fit tightly across the palm and/or wrist can cause muscle strain during instrumentation. It is best to wear right- and left-fitted gloves that are loose-fitting across the palm and wrist. The index finger of the opposite hand should slip easily under the wrist area of a gloved hand.[29]

Hand exercises after dental procedures are among the least-known ergonomic techniques for dental professionals. Well-controlled muscles have improved control and endurance, allowing for free wrist movement, and reduce the likelihood of injury. Hand exercises could help dentists to develop and maintain muscle strength for instrumentation. These exercises use power putty, a silicone rubber material that resists both squeezing and stretching forces. A full grip (to exercise the flexor muscle), finger extension (for the extensor muscle), and spreading of all fingers (for the extensor and abductor muscles) can be performed no more than 10–20 minutes after the last clinical session. While exercising, the hands should be maintained at waist level.[29]

The respondents' lack of awareness in the present survey regarding proper gloving and hand exercises following dental procedures was remarkable. The correlation of donning gloves incorrectly with prevalence of wrist pain was found to be statistically significant (Table 7). Though the correlation between lack of hand exercise and wrist pain was statistically insignificant (Table 7), a positive correlation could not be completely denied. No reports have been published indicating that proper gloving techniques and hand exercises after dental procedures are causal/preventive measures of MSDs.

Ways to improve posture

Numerous strategies have been proposed to prevent the multifactorial problem of dental operators developing MSDs.[14] These consist of postural awareness techniques, positioning strategies, and periodic breaks and strengthening exercises. Postural techniques include maintaining a low back curve when sitting (this prevents low back pain), use of magnification, and proper adjustment of the operator chair.

Magnification helps to improve the ergonomic posture. When operating without magnification, the head and neck tend to be held in an unbalanced forward position. In this posture, the vertebrae cannot properly support the spine, causing shoulder-stabilizing muscles to fatigue quickly. Other muscles compensate to stabilize the neck and shoulder, making them tight and painful and leading to tension neck syndrome (TNS).[22] Properly designed magnification systems can enhance the operator's working posture.[22]

Studies have revealed that an increase in operator pain could be due to longer work periods without breaks, due in part to the use of four-handed dentistry techniques.[4,6]

To prevent injury to muscles and other tissues, the operator should allow for rest periods to replenish and nourish the stressed structures. Directional stretches should be performed regularly throughout the day, both in and out of the operator setting. Specific strengthening exercises for the trunk and shoulder girdle enhance the health and integrity of the spinal column and optimize the function of the arms and hands.

Conclusion

The results of the present study revealed an alarming prevalence of 91% of MSDs among the respondent dentists, with the neck and back reported as the areas of greatest pain. Also, improper postures are routinely practiced by dentists while working long hours in PSPs. To effectively prevent MSDs in dentistry, prevention strategies and ergonomic techniques must address the postural and positioning difficulties as well as the detrimental physiological changes. Education and additional research also are needed to promote an understanding of the complexity of the problem and to address its multifactorial nature. Future studies should include longitudinal reports of body pain in clinicians, as well as the interplay between mechanical ergonomic factors and mental stress.

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References

1. Akesson I, Johnsson B, Rylander L, Moritz U, Skerfving S. Musculoskeletal disorders among female dental personnel—Clinical examination and a five-year follow-up study of symptoms. Int Arch Occup Environ Health 1999;72(6):395-403.
2. Alexopoulos EC, Stathi I, Charizani F. Prevalence of musculoskeletal disorders in dentists. BMC Musculoskelet Disord 2004;5:16.
3. Fish DR, Morris-Allen DM. Musculoskeletal disorders in dentists. NY State Dent J 1998;64(4):44-48.
4. Finsen L, Christensen H, Bakke M. Musculoskeletal disorders among dentists and variation in dental work. Appl Ergon 1997;29(2):119-125.
5. Lalumandier JA, McPhee SD, Parrott CB, Vendemia M. Musculoskeletal pain: Prevalence, prevention, and differences among dental office personnel. Gen Dent 2001;49(2):160-166.
6. Marshall ED, Duncombe LM, Robinson RQ, Kilbreath SL. Musculoskeletal symptoms in New South Wales dentists. Aust Dent J 1997;42(4):240-246.
7. Van Doorn JW. Low back disability among self employed dentists, veterinarians, physicians and physical therapists in the Netherlands: A retrospective study over a 13-year period (N = 1,119) and an early intervention program with 1-year follow-up (N = 134). Acta Orthop Scand Suppl 1995;263:1-64.
8. Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sorensen F, Andersson G, Jorgensen K. Standardised Nordic questionnaires for the analysis of musculosketal symptoms. Appl Ergon 1987;18(3):223-227.
9. Valachi B, Valachi K. Mechanisms leading to musculoskeletal disorders in dentistry. J Am Dent Assoc 2003;134(10):1344-1350.
10. Rundcrantz B, Johnsson B, Mortiz U. Cervical pain and discomfort among dentists: Epidemiological, clinical and therapeutic aspects. Part 1. A survey of pain and discomfort. Swed Dent J 1990;14(2):71-80.
11. Finsen L, Christensen H, Bakke M. Musculoskeletal disorders among dentists and variation in dental work. Appl Ergon 1998;29(2):119-25.
12. Chowanadisai S, Kukiattrakoon B, Yapong B, Kedjarune U, Leggat PA. Occupational health problems of dentists in Southern Thailand. Int Dent J 2000;50(1):36-40.
13. Rising DW, Bennett BC, Hursh K, Plesh O. Reports of body pain in a dental student population. J Am Dent Assoc 2005;136(1):81-86.
14. Valachi B, Valachi K. Preventing musculoskeletal disorders in clinical dentistry: Strategies to address the mechanisms leading to musculoskeletal disorders. J Am Dent Assoc 2003;134(12):1604-1612.
15. Leggat PA, Smith DR. Musculoskeletal disorders self reported by dentists in Queensland, Australia. Aust Dent J 2006;51(4):324-327.
16. Werner RA, Hamann C, Franzblau A, Rodgers PA. Prevalence of carpal tunnel syndrome and upper extremity tendonitis among dental hygienists. J Dent Hyg 2002;76(2):126-132.
17. Rundcrantz BL. Pain and discomfort in the musculoskeletal system among dentists. Swed Dent J Suppl 1991;76:1-102.
18. Milerad E, Ekenvall L. Symptoms of the neck and upper extremities in dentists. Scand J Work Environ Health 1990;16(2):129-134.
19. American Dental Association. Survey of current issues in dentistry: Repetitive motion injuries. Chicago:ADA Survey Center;1997:2-8.
20. Wijnhoven HA, de Vet HC, Smit HA, Picavet HS. Hormonal and reproductive factors are associated with chronic low back pain and chronic upper extremity pain in women—The MORGEN study. Spine 2006;31(13):1496-1502.
21. Jacobsen N, Hensten-Pettersen A. Occupational health problems among dental hygienists. Community Dent Oral Epidemiol 1995;23(3):177-181.
22. Valachi B. Magnification in dentistry: How ergonomic features impact your health. Available at: http://www.dentistrytoday.com/ergonomics/1110. Accessed May 23, 2011.
23. Lehto TU, Helenius HY, Alaranta HT. Musculoskeletal symptoms of dentists assessed by a multidisciplinary approach. Community Dent Oral Epidemiol 1991;19(1):38-44.
24. Gehrig NJS. Principles of positioning. *In:* Nield-Gehrig JS. Fundamentals of periodontal instrumentation and advanced root instrumentation, ed. 6. Philadelphia: Lippincott Williams and Wilkins;2008:11-48.
25. Daniel SJ, Nunn PJ, Berry RM. Positioning and prevention of operator injury. *In:* Daniel SJ, Harfst SA, Wilder RS. Mosby's dental hygiene—Concepts, cases and competencies, ed. 2. Philadelphia: Mosby Elsevier;2008:149-168.
26. Dong H, Loomer P, Villanueva A, Rempel D. Pinch forces and instrument tip forces during periodontal scaling. J Periodontol 2007;78(1):97-103.
27. Roquelaure Y, Mechali S, Dano C, Fanello S, Benetti F, Bureau D, Mariel J, Martin YH, Derriennic F, Penneau-Fontbonne D. Occupational and personal risk factors for carpal tunnel syndrome in industrial workers. Scand J Work Environ Health 1997;23(5):364-369.
28. Silverstein BA, Fine LJ, Armstrong TJ. Occupational factors and carpal tunnel syndrome. Am J Ind Med 1987;11(3):343-358.
29. Gehrig NJS. Instrument grasp. *In:* Nield-Gehrig JS. Fundamentals of periodontal instrumentation and advanced root instrumentation, ed. 6. Philadelphia: Lippincott Williams and Wilkins;2008:48-64.
30. Mastuda SA. Instruments and principles of instrumentation. *In:* Wilkins EM. Clinical practice of the dental hygienist, ed. 9. Philadelphia: Lippincott Williams and Wilkins;2005:609-644.

Exercise No. 296

Practice Management

Subject Code 550

The 15 questions for this exercise are based on the article "Correlation of awareness and practice of working postures with prevalence of musculoskeletal disorders among dental professionals" on pages 476-483. This exercise was developed by Gustav E. Gates, DDS, MAGD, in association with the *General Dentistry* Self-Instruction committee.

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

- increase your awareness of the prevalence and distribution of musculoskeletal disorders (MSDs) among dental professionals;
- recognize the causes of MSDs; and
- identify changes that dentists can make to reduce MSDs.

1. This study evaluated MSDs in all but which of the following areas of the body?
   A. Neck
   B. Hip
   C. Shoulder
   D. Back

2. Neutral position—the ideal positioning of the body to decrease the risk of musculoskeletal injury—includes all but which of the following?
   A. Forearms parallel to the floor
   B. Head tilted 20 degrees to the floor
   C. Heels resting flat on the floor
   D. Thighs parallel to the floor

3. What percentage of the 500 dentists in this study suffered from MSDs?
   A. 27
   B. 56
   C. 72
   D. 91

4. How many dentists in this study had back or shoulder pain?
   A. 32
   B. 159
   C. 263
   D. 335

5. Wrist problems showed the lowest incidence at 6%. Shoulder pain had the highest incidence at 32%.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

6. The most common mistake dentists made regarding incorrect posture was not using the
   A. upper arm position.
   B. neutral position.
   C. position of back.
   D. position of shoulder.

7. What percentage of the dentists who had no MSDs practiced most of the ergonomic postures in a correct way?
   A. 55
   B. 65
   C. 75
   D. 85

8. The position of the patient in the chair was the most important factor in dentists having no problems with MSDs. This was followed by the correct posture in holding instruments.
   A. Both statements are true.
   B. The first statement is true; the second is false.
   C. The first statement is false; the second is true.
   D. Both statements are false.

9. How many dentists in this study had neck problems caused by incorrect position of the patient in relation to the operator?
   A. 111
   B. 122
   C. 134
   D. 160

10. Of the dentists who experienced no MSDs, which technique did they practice correctly?
    A. Gloves used
    B. Holding of instrument
    C. Position of back
    D. Foreman position

11. **Musculoskeletal pain has been attributed to various risk factors, including all but which of the following?**
    A. Repetitive movements
    B. Genetic predisposition
    C. Prolonged static postures
    D. Duration of practice

12. **Neck pain in dentists and hygienists can be attributed to operating with a forward head position of at least ___ degrees for ___ % of their time in the operatory.**
    A. 10, 65
    B. 20, 75
    C. 25, 95
    D. 30, 85

13. **Prevalence of back problems was attributed to all but which of the following incorrect postures?**
    A. Improper positioning of the patient
    B. Position of the back
    C. Neck tilted forward
    D. Maintenance of a neutral position

14. **Only general dentists were included in this study. One hundred participants had more than 10 years of experience.**
    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.

15. **Correct hand exercises include all but which of the following?**
    A. Exercising for 10 minutes before the clinical session
    B. Holding hands at waist level
    C. Grasping a silicone rubber material ball
    D. Spreading all the fingers with a full grip

Instructions are on page 431.
Answer form is on page 512.
Answers for this exercise must be received by October 31, 2012.

The role of volume of multi-surface restorations in posterior teeth: Treatment options

Charles Janus, DDS, MS, MS ▪ Izzat Sbeih, DDS ▪ Al M. Best, PhD

Teeth containing large defective restorations are frequently indicated to receive crowns to prevent catastrophic fracture. There is a considerable lack of consensus as to when the size of an existing restoration needing retreatment is sufficiently large to warrant a crown. In addition, the treating dentist's gender, age, and location also have been found to influence this decision. An *in vitro* method was developed to estimate a restoration's volume proportion (VP). This study validates and investigates correlations between the restoration's VP, the decision to indicate a crown, and the responding dentist's demographic information.

The coronal portions of occlusal view and bitewing radiographic images of restored posterior teeth were traced to yield four surface areas used in estimating the restoration's VP. An online survey of 15 patients, including intraoral and radiographic images of defective restorations, was created. Dentists were invited to select treatment for each patient's tooth, with options including replacing the restoration only or indicating a crown. Analysis was accomplished using repeated-measures logistic regression. Of the 300 respondents, 17% were female and 14% were from outside the U.S. The relationship between a responding dentist indicating a crown and the restoration's VP, the tooth type (molar or premolar), and nationality (U.S. or foreign dentist) were all deemed statistically significant. Crowns were indicated for molars significantly more often than for premolars, with a significant VP interaction. The final model of tooth, VP, nationality, and the interaction of tooth and VP was used to generate mean predicted proportions for indicating a crown.

Received: July 13, 2010
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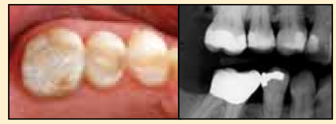
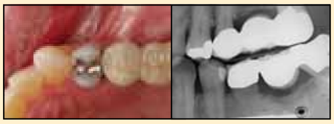
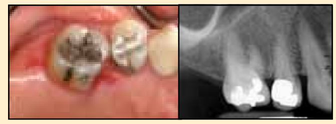
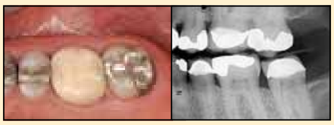
Dentists routinely encounter patients whose teeth contain large restorations that need to be replaced for a variety of reaons.[1,2] The treatment choice for tooth restoration can be influenced by many factors, including the existing oral conditions, extent of new disease, and the patient's desires and resources.[2] Although the likelihood of "catastrophic" fracture is low, the replacement restoration can be large enough to predispose the remaining tooth structure to fracture during function, and a full-coverage crown is often recommended to reduce this possibility.[2-6] However, there is a considerable lack of consensus as to when a restoration's size is sufficient to warrant crown placement, for reasons that include the fact that bonded restorations are sufficient to prevent tooth fracture, variation in reasons for crown placement, or difficulty in estimating the size of the existing restoration.[7-10] Even demographic factors, such as the dentist's gender, graduation year, and practice location can influence treatment decisions.[11]

Although indicators such as parafunctional habits, occlusal wear, and tooth morphology are not significant predictors of risk for fracture, two other indicators have a strong association with the risk of fracture: the presence of an existing fracture line in the remaining tooth structure, and the coronal volume of the restoration as compared to that of the remaining tooth.[12]

A 2003 *in vitro* investigation explored a method of estimating the restoration's volume in relationship to the coronal tooth structure. Using melamine typodont teeth, the exact volume of restorative material was calculated for various cavity preparations and then compared to an estimated volume calculated from tracings of occlusal and bitewing radiographic images of the restored teeth. These tracings and subsequent calculations yielded an estimate of the restoration's volume proportion (VP) that, when compared to the true VP, yielded a significantly high correlation of 0.97.[13]

The ability to estimate the restoration's size and compare it to the accumulated wisdom of the profession through a survey of treatment choices by many dentists could provide a more quantitative strategy for indicating a full-coverage crown. Therefore, the present study sought to poll the restorative choices of dentists for specific teeth and investigate possible correlations of these choices to both the VP and other demographic information about the dentists, such

Chart 1. Calculated VP values for each premolar case, including tooth and radiographic images.

Tooth	VP	Image	Tooth	VP	Image
First premolar	0.079		Second premolar	0.270	
First premolar	0.162		First premolar	0.312	
Second premolar	0.205		First premolar	0.345	

as year of graduation, gender, office location, and practice type.

Materials and methods

To acquire examples of posterior teeth containing restorations of various sizes, patients were chosen who had conventional restorations and current bitewing radiographs. A bitewing radiograph and occlusal-view digital photograph were taken of each patient's tooth. Each analog radiograph was photographed to create a digital image. All intraoral digital photography and digital images of each radiograph were taken with a 20D digital camera with a 100 mm macro lens (Canon U.S.A., Inc.).

The following method was used to estimate the VP: First, the restoration outline and coronal portion of the tooth were traced on each occlusal view and radiographic digital image using image tracing software by UTHSCSA Image Tool for Windows, version 3.0, from the University of Texas Health Science Center San Antonio. The accuracy of the image tracing software was confirmed by multiple tracings of the same area yielding numbers that varied by less than 2% from the mean.

Next, four individual surface areas were traced for each tooth: the surface area of the restoration in both the occlusal and bitewing radiograph views, and the surface area of the coronal portion of the tooth in both the occlusal and bitewing radiograph views. The same investigator completed all tracings and each area was traced three times, with the average of the three tracings used in the calculations to estimate VP. When tracing an endodontically treated tooth, pulpal and radicular spaces were not included. When the CEJ was not visible, the apical extent of the restoration was taken as the apical landmark. If a sedative base was visible in the radiographic image, it was included in the tracing as part of the restoration.

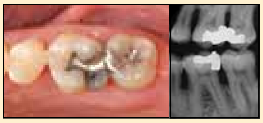
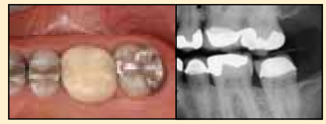
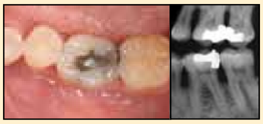
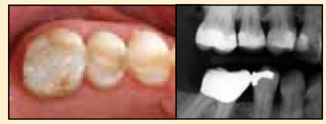
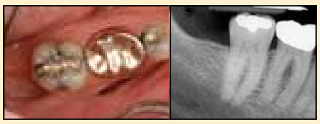
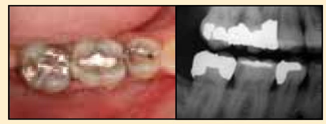
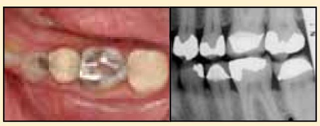
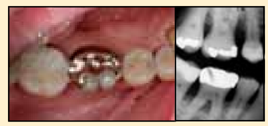
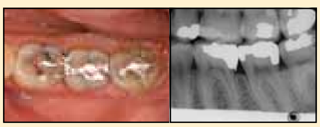
Finally, the surface area of the restoration was divided by the surface area of the coronal portion of the tooth for each view, and these two numbers were multiplied to calculate the overall estimate of VP for each tooth. Charts 1 and 2 list the VP estimates for each premolar and molar tooth in addition to the images used in the survey.

The online survey was created using the Inquisite Web Survey System, version 6.5 (Inquisite Inc.). The survey contained 15 cases and included intraoral and radiographic images of each tooth. **Respondents were given the following instructions:**

In each of the following 15 cases, a tooth and the problem are described in the accompanying text. After reading the description and viewing the photograph and bitewing radiograph, choose from the drop-down menu the treatment you would recommend assuming a patient who has optimum health, no clinical symptoms, ideal occlusion, no parafunctional habits, good home care, and sufficient resources to afford any treatment you propose.

Each case was accompanied with a brief description, including the patient's age and gender, the tooth needing retreatment, and the following clarification: "Although this will include the complete removal of the existing restoration, you expect very little extension of the cavity preparation." The respondent was

Chart 2. Calculated VP values for each molar case, including tooth and radiographic images.

Tooth	VP	Image	Tooth	VP	Image
First molar	0.086		Second molar	0.353	
First molar	0.096		First molar	0.387	
Second molar	0.098		Second molar	0.417	
First molar	0.225		First molar	0.590	
Second molar	0.272				

then asked to select one of the following treatment options:

- Replace the restoration with amalgam
- Replace the restoration with composite resin
- Replace the restoration with a metal inlay or onlay
- Replace the restoration with a nonmetal (resin or ceramic) inlay or onlay
- Replace the restoration and place an all-metal crown
- Replace the restoration and place a porcelain-fused-to-metal crown
- Replace the restoration and place an aluminum or zirconium oxide crown
- Replace the restoration and place a Lucite-reinforced crown
- Other (specify)

The concluding portion of the survey asked responding dentists to disclose information about themselves, including their year of graduation from dental school, gender, zip code, formal post-doctorate training, and specific practice type.

A link to the survey was provided to representatives of Dentaltown.com, Inc. (Towniecentral.com, L.L.C.), an online publishing company with national and international subscribers. The survey was advertised and subscribers were invited to participate.

The data set preparation and analysis were accomplished using SAS software (SAS 9.1 and JMP 7.0, SAS Institute, Inc.). All analysis took into account that multiple cases were presented to each individual surveyed. The significance of factors related to the choice of crown versus restoration was tested using repeated-measures logistic regression (PROC GENMOD with an exchangeable correlation GEE structure, SAS Institute, Inc.).

Results

A total of 300 dentists responded to the survey; 285 respondents reported providing fixed prosthodontic care. Overall, 14% of the respondents were from outside the U.S. and represented 13 other countries: Canada, Australia, Brazil, Ireland, New Zealand, the United Kingdom, Argentina, the Bahamas, Israel, Malaysia, Norway, Peru, and Serbia. Approximately 17% of respondents were female, with a similar distribution in the United States and foreign countries.

Chart 3 illustrates the distribution of the years of graduation, which ranged from 1923 to 2008. The overwhelming majority of respondents were private practioners in either solo (58%) or group

Chart 3. Distribution of responding dentists' dental school graduation year.

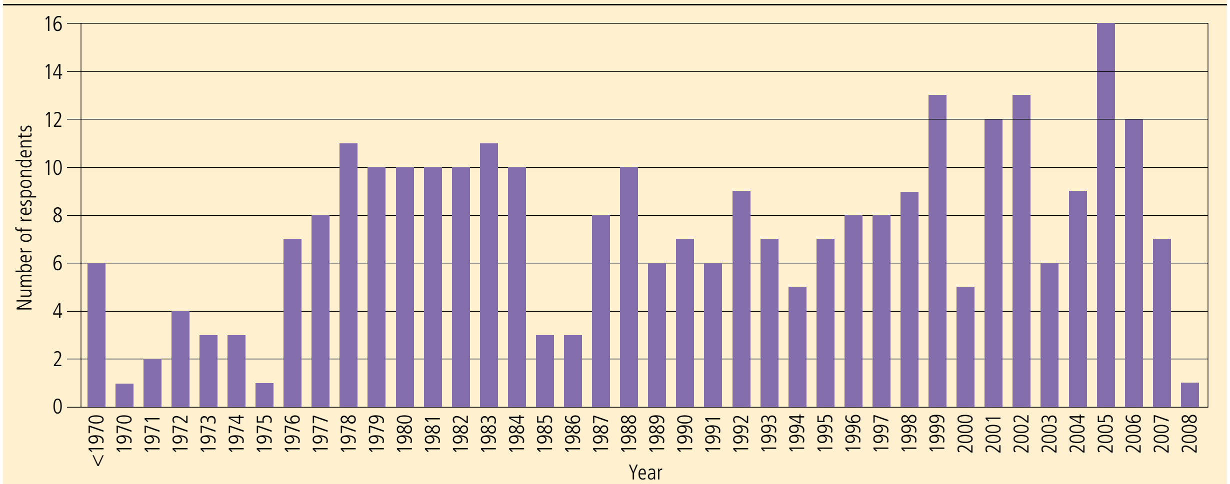
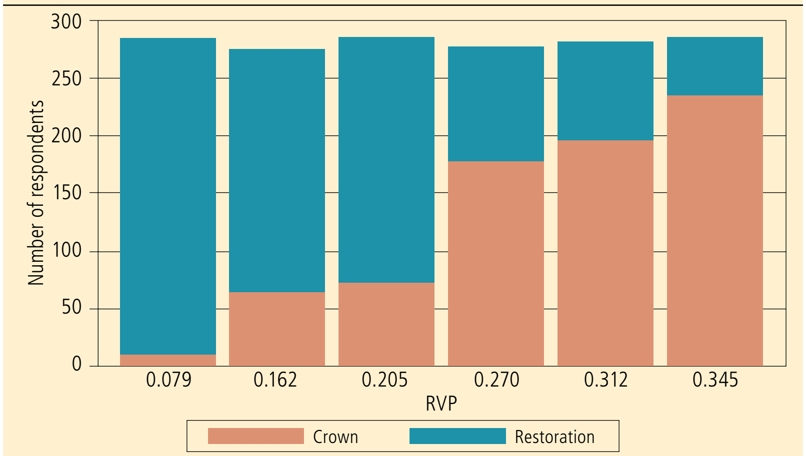


Chart 4. Distribution of responding dentists' decision to place a crown or a restoration versus VP (premolars only)



practice (35%); the remainder of respondents reported their setting as Dental Education, Hospital-based Practice, Military, Dental Company, Other, or Retired. Most of the respondents reported general dentistry as their primary practice discipline (93%); the remainder responded with Prosthodontics, Endodontics, Oral Surgery, Pedodontics, Periodontics, or Other.

The number of responding dentists indicating a crown or a restoration versus the VP for all 15 cases is illustrated in Chart 4 for premolars and in Chart 5 for molars.

Preliminary analysis using repeated-measures logistic regression revealed a significant relationship between whether a respondent indicated a full crown, the tooth's VP, and the tooth type (molar or premolar) ($P < 0.0001$). Additionally, crowns were indicated for molars significantly more frequently than for premolars ($P < 0.0001$), and the interaction between VP and tooth type was found to be significant ($P < 0.0001$).

The initial model was then used to test other variables. The nationality of respondents was found to be significant; that is, dentists practicing in the U.S. indicated crowns significantly more often than dentists practicing outside the U.S. ($P = 0.0008$). Male dentists indicated crown restorations slightly more frequently than female dentists; however, the difference was not significant ($P = 0.6345$). The respondent's decade of graduation also was insignificant in the decision to place a crown ($P = 0.3285$). Solo practioners indicated crowns more often when compared to all other respondents grouped together; this finding was significant ($P = 0.047$) but became insignificant when adjusted for VP, gender, tooth type, and nationality ($P = 0.0555$). The score statistics for the final model appear in Table 1.

Using the final model with the independent variables of tooth, VP, nationality, and the interaction of tooth and VP, mean predicted proportions of U.S. and non-U.S.

Chart 5. Distribution of responding dentists' decision to place a crown or a restoration versus VP (molars only)

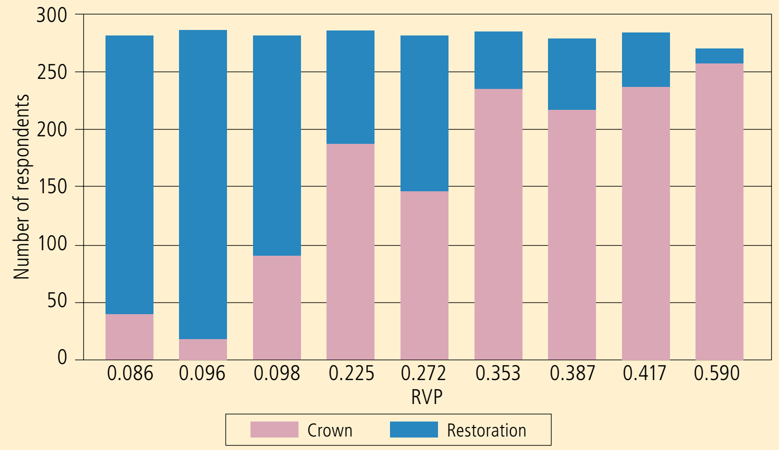


Table 1. Score statistics for Type 3 GEE analysis.

Source	df	Chi-square	*P* value
Nationality (U.S. or non-U.S.)	1	11.32	0.0008
Tooth (molar or premolar)	1	78.23	<0.0001

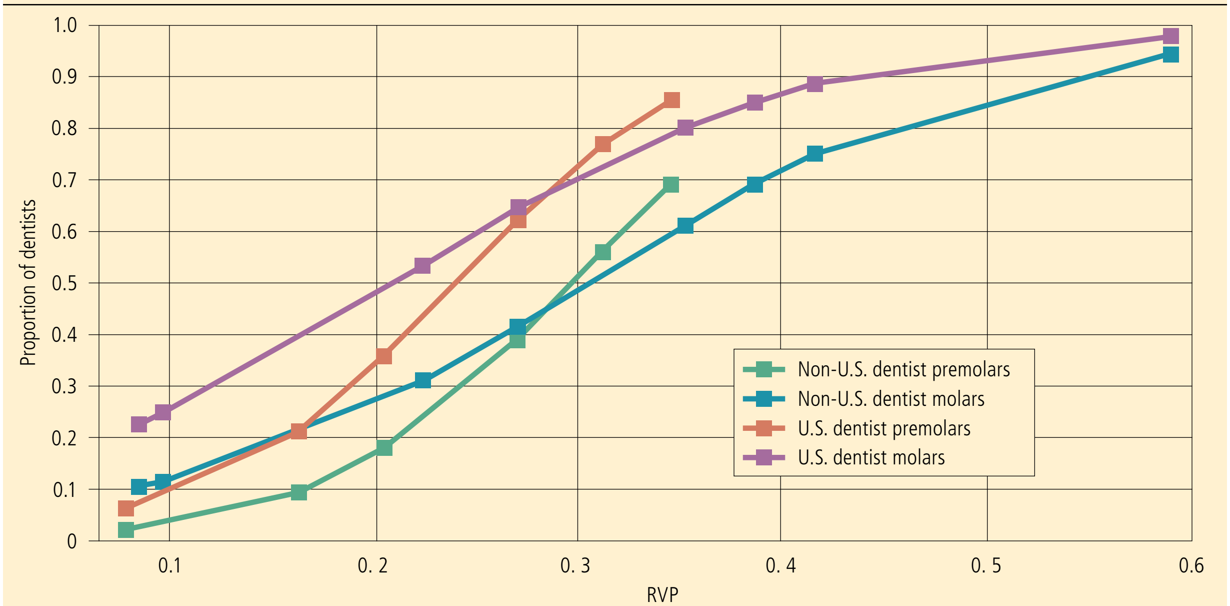
dentists treating molars and premolars compared to the tooth's VP were generated and are shown in Chart 6.

Discussion

The results of this study indicate a significant relationship between the size of the existing restoration and the percentage of dentists who recommend a full crown. That said, as seen in Charts 3 and 4, some dentists still recommend crowns on teeth with very small VPs, while other dentists recommend a restoration only on teeth with large VPs. This variation in treatment recommendations suggests an experienced-based decision process that could result from a number of reasons, including difficulty in clearly estimating the size of the existing restoration and assessing the consequent risk of the remaining tooth fracturing if a crown is not placed.

Crowns were indicated for molars significantly more often than for premolars. This finding suggests that

Chart. 6. Mean predicated proportions of responding dentists indicating crowns on teeth, displayed by U.S. versus non-U.S. respondents treating molars or premolars, versus VP.



molars might sustain more extensive damage than premolars and, due to their position in the arch, are subject to greater occlusal forces during function, thus requiring the additional protection afforded by a complete crown.

While factors such as dental history, parafuctional habits, and anticipated occlusal forces could influence the choice between placing a large restoration or placing a full-coverage crown, the results of this study support the possibility of developing a more quantitative tool to assess a tooth and restoration and therefore providing a more evidence-based method to judge when a crown is genuinely indicated. Not only would this help with individual teeth needing restoration, it also would be extremely beneficial when assessing teeth to serve as potential abutments and the subsequent increase in functional load. With additional research, it may be possible to develop a decision tree of variables to offer both dentists and patients greater certainty and confidence in making this treatment choice.

Conclusion

Respondents to this survey indicated crown restorations on molars significantly more often than on premolars. Respondents outside the U.S. indicated crowns significantly less frequently than those in the U.S. The VP of the existing defective restoration was highly significant in the dentist's decision between simply replacing the restoration and adding the placement of a full-coverage crown.

Author information

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References

1. Wilson NH, Burke FJ, Mjor IA. Reasons for placement and replacement of restorations of direct restorative materials by a selected group of practitioners in the United Kingdom. Quintessence Int 1997;28(4):245-248.
2. Clarkson JE, Worthington HV, Davies RM. Restorative treatment provided over five years for adults regularly attending general dental practice. J Dent 2000;28(4):233-239.
3. Bader JD, Shugars DA, Sturdevant JR. Consequences of posterior cusp fracture. Gen Dent 2004;52(2):128-131.
4. Caron GA, Murchison DF, Cohen RB, Broome JC. Resistance to fracture of teeth with various preparations for amalgam. J Dent 1996;24(6): 407-410.
5. Wahl MJ, Schmitt MM, Overton DA, Gordon MK. Prevalence of cusp fractures in teeth restored with amalgam and with resin-based composite. J Am Dent Assoc 2004;135(8):1127-1132.
6. Bader JD, Martin JA, Shugars DA. Incidence rates for complete cusp fracture. Commun Dent Oral Epidemiol 2001;29(5):346-353.
7. Dias de Souza GM, Pereira GD, Dias CT, Paulillo LA. Fracture resistance of premolars with bonded Class II amalgams. Oper Dent 2002;27(4): 349-353.
8. Kronstrom M, Palmqvist S, Soderfeldt B. Prosthodontic decision making among general dentists in Sweden. I: The choice between crown therapy and filling. Int J Prosthodont 1999;12(5):426-431.
9. Covey DA, Kent DK, Dunning DG, Koka S. Qualitative and quantitative determination of dental amalgam restoration volume. J Prosthet Dent 1999;82(1):8-14.
10. Witter DJ, Kreulen CM, Creugers NH. Fracture risk judgment and crown indication by teachers in a dental school: A pilot study. Int J Prosthodont 2005;18(2):161-162.
11. Rosenstiel SF, Land MF, Rashid RG. Dentists' molar restoration choices and longevity: A web-based survey. J Prosthet Dent 2004;91(4): 363-367.
12. Bader JD, Shugars DA, Martin JA. Risk indicators for posterior tooth fracture. J Am Dent Assoc 2004;135(7):883-892.
13. Sturdevant JR, Bader JD, Shugars DA, Steet TC. A simple method to estimate restoration volume as a possible predictor for tooth fracture. J Prosthet Dent 2003;90(2):162-167.

Manufacturers

Canon U.S.A., Inc., Lake Success, NY
800.652.2666, usa.canon.com

Inquisite Inc., Austin, TX
512.328.2943, www.inquisite.com

SAS Institute, Inc., Cary, NC
919.677.8000, www.sas.com

Towniecentral.com, L.L.C., Phoenix, AZ
480.598.0001, www.towniecentral.com

Head and neck cancer in two American presidents: Case reports

Mea A. Weinberg, DMD, MSD, RPh ▪ Beverly Wang, MD, MSc

Two former U.S. presidents, Ulysses S. Grant and Grover Cleveland, were diagnosed with head and neck cancer in 1884 and 1893, respectively. A historical review of the risk factors, diagnoses, and treatments is examined and compared with modern-day interpretations. A comparison was made using the original diagnoses with today's equivalent diagnosis. Different treatment outcomes at the time of the original diagnoses relative to today's treatment are reviewed. Clinicians must be familiar with risk factors, signs, symptoms, diagnosis, and treatment of head and neck cancer.

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Only two U.S. presidents have ever been diagnosed with oral or oropharyngeal cancer: Ulysses S. Grant and Grover Cleveland, and only Grant died of the disease. In fact, Americans first became aware of the dangers of smoking and drinking when Grant was diagnosed in 1884. This article discusses the different oral tumors, treatments, and outcomes for both presidents.

General Ulysses S. Grant

Ulysses S. Grant (aka Hiram Ulysses Grant; the "S" is alleged to stand for "Simpson," his mother's maiden name) was born in Point Pleasant, Ohio, on April 27, 1822, and served as the 18th U.S. president from March 4, 1869 to March 4, 1877.

In 1848, Grant married Julia T. Dent in St. Louis, Missouri. As a first lieutenant in the infantry during the Mexican War, he was transferred to California and Oregon. Supposedly because he was lonely and sad without his wife and family, he began drinking. In 1854, he resigned his commission because of rumors of drunkenness while on duty and moved back to St. Louis.[1]

It should be noted that in the early 19th century, daily alcohol consumption in the U.S. was not unusual and actually was considered to be a standard, "normal" habit. People believed alcohol "washed down food that was often poorly cooked, greasy, salty, and sometimes rancid."[2]

On June 2, 1884, in Long Branch, New Jersey, at the age of 62, Grant complained of a sore throat and facial pain on the right side when he bit into a peach. Weeks later, he continued to have these symptoms, which included dryness in the throat.[3,4] Dr. J.M. DaCosta examined Grant and found a mass at the base of the tongue. However, Grant did not go to his personal physician, Dr. Fordyce Barker, until October. At this time, Grant's right submandibular lymph node was palpable and referred pain to the right ear. He was referred to John H. Douglas, MD, a New York otolaryngologist.[5] By December 1884, the condition had worsened.

Grant had started smoking cigars at a very early age; later in life, he admitted to smoking up to 12 cigars a day.[6] After winning the Battle of Donelsen, he was given 10,000 Cuban cigars; some were given away, but he ended up smoking many himself. There are accounts that Grant actually may have been a pipe smoker prior to the capture of Fort Donelson.[7] According to Douglas, Grant's smoking most likely was the primary risk factor for the cancer, rather than alcohol consumption, which he did not believe was excessive.[6]

Grant and his family moved to Mount McGregor, near Saratoga Springs, New York, in June 1885. This is where he finished his memoirs and subsequently died on July 23, 1885, 13.5 months after his diagnosis.

Diagnosis

Grant's lesion was initially diagnosed by Douglas in October 1884, based solely on clinical findings without biopsy. Upon initial examination, **Douglas described the lesion of the right tonsillar fossa as follows:**

I found the velum inflamed, of a dark, deep congestive hue, a scaly squamous inflammation strongly suggestive of serious epithelial trouble…when palpated, was found to be swollen, and hard at the base, and to the right side.[6,8]

Palliative treatment was recommended.[8,9] By December 1884, the cancer had spread to the posterior pillar of the fauces, tonsillar space, and soft palate, making eating difficult. The base of the anterior pillar was perforated, and the right side of the base of the tongue was indurated.[8,9]

On February 18, 1885, Dr. Douglas (in New York) performed an incisional biopsy; pathology findings were reported by Dr. George R. Elliott.[10] The biopsy was examined under a microscope that, at the time, was not commonly used. The diagnosis was "epithelioma of the squamous variety."[10] Microscopic examination at this time was considered a novice technique and not yet widely used.[11]

The histopathologic slides from the original biopsy (right base of the tongue) were reexamined in July 2000 by the Armed Forces Institute of Pathology.[12] The new description of the tissue emphasized the pattern of cell growth as an irregular interconnected trabecular growth as compared to a lobular, cell nest pattern of growth as described by Dr. Elliott. Additionally, the more recent observations indicated a significantly pronounced mitotic rate and presence of atypical mitoses. Both observations verify the malignancy of the tumor, classified as squamous cell carcinoma poorly differentiated by modern pathology.

According to edition six of the tumor, node, and metastasis (TNM) classification and staging of head and neck cancers, Grant's tumor would be classified as T_1N_1 (T_1: tumor 2.0 cm or less; N_1: metastasis in a single ipsilateral regional lymph node, 3.0 cm or less in greatest dimension), or Stage III.[13] As the tumor spread, it would be classified as Stage IV.[13]

Treatment

There were not many treatment options for oral and oropharyngeal cancer in the 1800s. Radiation and chemotherapy did not exist, and surgical removal of the tumor consisted of splitting the angle of the mandible and subsequent resection of the entire tongue, most of the soft palate, and the ulcerated fauces and glands under the right angle of the mandible.[8] Dr. George F. Shrady, a surgeon, summarized the operation that would have taken place; however, this surgical option was not chosen because it most likely would have incapacitated Grant and reduced his quality of life from the severe shock of the surgery, prompting Shrady to write that "in the best interests of the distinguished patient the surgeons did not feel inclined to recommend the procedure."[9] For this reason, Grant received only palliative treatment.

Grant was in terrible pain, especially when he swallowed. Eating was very difficult, even with a soft diet. After the clinical diagnosis was made, Grant was treated by smoking cessation, reducing his smoking to three cigars per day; he even stopped smoking for a time. Eventually, topical application of 4% cocaine hypochlorite solution did not anesthetize the area adequately, and topical antiseptic iodoform powder was used.[11] Additionally, different gargles were used, including salt water, diluted carbolic acid, and permanganate of potash and yeast.[11] Today, carbolic acid is recognized as a toxic irritant and anesthetic, while permanganate of potash is referred to as *potassium potash crystals,* a toxic disinfectant and antiseptic.

Grant's greatest fear was that he would choke on his own salivary secretions.[3] His secretions were removed continuously with swabs and expectoration. He had continuous attacks of choking and on March 30, 1885, he had a severe attack and became very weak. Digitalis was judged ineffective, so injections of brandy were administered as a cardiac stimulant.[4,9] In fact, Dr. Barker was the first physician in the U.S. to administer medications by hypodermic injection.[3] Grant almost died from a hemorrhage in his throat on April 7, 1885.[9] To help with his insomnia, Grant was given codeine, morphine, sodium bromide (used as a sedative in the late 19th and early 20th centuries), and chloral (a sedative/hypnotic agent that becomes chloral hydrate upon reacting with water).[6]

Modern treatment

The only treatment option at the time of Grant's diagnosis was surgery because radiation had not yet been discovered. But as previously discussed, surgery was not conducted because of Grant's position in society and the risk of significant morbidity with the loss of a major organ function, including swallowing and speech.[14] Today's treatment for Grant's SCC of the base of the tongue/tonsil/posterior pharyngeal wall/soft palate (initial Stage III) depends on the stage of involvement and overall time of treatment.[14] Today, update management for T_1N_1 SCC/base of tongue remains surgery.[15,16]

Other approaches include radiation therapy, excision of primary tumor with or without unilateral neck dissection with adjunctive postoperative radiation therapy, or radiation therapy plus systemic chemotherapy, or radiation therapy followed by brachytherapy implantation or chemoradiation.[17-20] Positive results have been obtained by external beam irradiation followed by an interstitial implant boost and by external beam irradiation alone.[17]

The survival rate of patients with SCC of the base of the tongue depends on the tumor's stage.[21] Today, the tumor-specific, five-year survival rate for T_1N_1 lesions, which

Fig. 1. President Cleveland's tumor preserved in a jar in the Mutter Museum, College of Physicians of Philadelphia. (Courtesy of The College of Physicians of Philadelphia.)

Fig. 2. Dental casts of Cleveland's maxilla: *Left:* Initial defect after surgery in 1893. *Right:* Healing of defect, four years later. (Courtesy of the Malloch Rare Book Room of the New York Academy of Medicine Library.)

Grant had, is 80% with improved survival with early-stage disease.[18]

Today, reconstruction of the base-of-tongue defect after transhyoid resection is challenging to recover tongue mobility for speech and swallowing (challenging depending on the portion of tongue removed), to maintain the airway, and to prevent functional morbidity. Reconstruction is not necessary after transoral resection. Surgical reconstruction of the tongue base is accomplished by either primary closure of the residual tongue base to the lingual surface of the epiglottis or using skin grafts from various parts of the body, depending on the size of the defect.[22] Use of the radial forearm free flap in patients with large base-of-tongue lesions can lead to good functional speech and swallowing results.[23]

President Grover Cleveland

Stephen Grover Cleveland was born on March 18, 1837, in Caldwell, New Jersey. He was the only president to serve two nonconsecutive terms (22nd president in 1884 and 24th president in 1892). Cleveland was married in the White House in 1886.[24]

During the economic crisis of 1893, Cleveland discovered an ulceration on the left side of his hard palate. His physician, Major Robert M. O'Reilly, clinically described the ulceration extending from the molars to approximately 8.0 mm from the midline of the hard palate and with cauliflower granulations with crater edges.[25,26] The lesion measured 2.0–3.0 cm.[27] On June 19, 1893, a scraping of the lesion was performed and the sample was sent anonymously for histological evaluation to the Army Medical Museum in Washington, DC.[11] The results reported an "epithelial low grade malignancy."[3,11,26] Today, the tumor is in a jar at the Mutter Museum College of Physicians of Philadelphia (Fig. 1). Since the 1893 biopsy, several other diagnoses have been made, including keratocarcinoma and, most recently, verrucous carcinoma.[28]

Surgery

The only treatment option available was surgical removal. The surgical team consisted of Joseph Bryant, MD, the surgeon; W.W. Keen, MD, from Jefferson Medical College in Philadelphia, who assisted Dr. Bryant with the surgery; Dr. Ferdinard Hasbrouck, a dentist from New York, who administered the anesthesia and performed tooth extractions; and Robert O'Reilly, J.F. Erdmann (Bryant's assistant), and Dr. Edward Janeway, a New York physician. The surgery took place on July 1, 1893, in New York City on the yacht *Oneida,* owned by Cleveland's friend Elias C. Benedict. The trip started in the East River and ended at Buzzards Bay, Massachusetts. The operation was performed in secrecy because during a time of the financial crisis in America (the Panic of 1893), it was important for public perception that the president not be seen as "weak."[26] It must be noted that no special care was given for infection control at that time.

Drs. Hasbrouck and O'Reilly administered a combination of nitrous oxide and ether and applied topical cocaine to the surgical site.[25,26] Surgical details were described in a book by Dr. Keen in 1917.[29] Surgically, the two premolars were extracted and intrasulcular incisions were made. Bleeding was stopped by pressure, hot water, and electrocautery.[30] A left-sided transoral partial maxillectomy was performed, including one-third of the hard palate, up to one-third of an inch from the midline, extending from the first premolar to beyond the third molar (by the tuberosity).[25,27] The tumor had extended around the roots of the molars and into the antrum.[25,27] A small part of the soft palate was excised exposing the antrum.[3,24] No lymph nodes were involved. The palatal osseous defect was packed with iodoform gauze.[3,24] The operation lasted 84 minutes, with a total blood loss of 6.0 oz.[30] One half grain of morphine was administered to the patient.[30]

Due to the large osseous defect on the palate (2.5 in. long and 13/16 in. wide), the president required an obturator to assist him in eating and talking (Fig. 2).[25] Prosthodontist Dr. Kasson C. Gibson fabricated a vulcanized rubber prosthesis.[3,30] A second surgery was performed to remove suspicious tissue, followed by recuperation at Cleveland's summer home at Buzzards Bay, MA.[25]

During the surgery, new instruments were used for the first time in the U.S. Cheek retractors from Paris (specifically, a Luer cheek retractor) enabled the surgeon to perform the surgery intraorally without external incisions (Fig. 3).[26,29] Other instruments utilized included a mirror-fortified electric light and an electrocautery.[8] Cleveland healed without consequences and lived for another 15 years.

Diagnosis

Cleveland's tumor was a well-differentiated form of SCC with a low metastatic potential and a more positive prognosis compared to Grant's tumor. The definitive diagnosis remains controversial; however, in 1980, Brooks *et al* concluded that the diagnosis was most likely verrucous carcinoma.[8,27]

In 1948, Ackerman first described a verrucous carcinoma as an unusual and indolent form of oral SCC, which actually might be the modern diagnosis of Cleveland's tumor.[28,31] Today, Cleveland's tumor would be classified as T_1N_0. Verrucous carcinoma is a relatively rare low-grade variant of well-differentiated SCC, with an incidence of 2.0–4.0%, being more common in the larynx and cervix.[8,27] It has an 18% frequency of occurrence on the palate.[32] Microscopically, the lesion is composed of highly differentiated squamous cells, with thickened surface keratinizing epithelium and penetrates into the subepithelial connective tissue.[33] Medina *et al* documented a 82% local control after surgery and a five-year survival rate of 74%.[34,35]

Modern treatment

Controversy exists as to whether Cleveland was overtreated because the tumor was thought to be malignant at the time, but it was concluded that the surgery likely saved his life.[36] Verrucous carcinoma is treated the same way today as it was in the 1800s, with surgical excision. Adjuvant radiotherapy can be added for larger lesions. Radiation therapy is given to unresectable tumors, to positive margins (the distance between the tumor and the edge of the tissue) after surgery, or if the patient refuses surgery. After surgical resection of the maxilla, the method of reconstruction may or may not be different from that given to Cleveland, depending on the size of the osseous defect.[37]

Fig. 3. Instruments (Luer cheek retractor and dental mirror) used during Cleveland's surgery. (Courtesy of The College of Physicians of Philadelphia.)

Today, a palatal osseous defect after resection can be grafted with bone and a membrane placed under the flap with subsequent placement of dental implants; however, primary closure of the wound might not be attainable with a defect as large (2.5 in long) as Cleveland's, leading to suboptimal palatal bone contours that could make prosthetic rehabilitation difficult (for example, placement of dental implants). An obturator would likely be the best treatment option for a final prosthesis to improve the patient's quality of life.[37]

Discussion

Undoubtedly, the risk factors for Grant's SCC were excessive alcohol consumption and smoking. One of the earliest publications relating smoking, in particular cigar smoking, to head and neck cancer appeared in 1915.[38] **The earliest reference specifically tracing alcohol as an etiological factor in head and neck cancer was Wynder *et al* in 1957:**

Alcohol has often been mentioned as a factor in the development of mouth cancer, but to our knowledge no adequate investigations with both study and control groups have been made to determine this particular point.[39]

Additionally, with changing sexual behaviors, there has been an increasing trend for the human papillomavirus (HPV) to be linked to the development of SCC/base of tongue and tonsils, especially in men.[40-43] HPV might actually be a cofactor with tobacco or a contributor in initiating malignancy.[44] A recent study found HPV-16 present in 72 of 100 oropharyngeal cancer patients.[45] HPV+ tumors are nonkeratinizing and could have a better prognosis than the classical keratinizing SCC.[42] Today, mortality in SCC of the oropharynx most often is due to failure to control localized disease. For this reason, aggressive management of the primary tumor and any cervical adenopathy with radiotherapy, surgery, or both is the usual protocol.[46]

President Cleveland smoked cigars and used chewing tobacco (snuff), which likely played a major role in the development of verrucous carcinoma.[31] The incidences of tobacco chewing, smoking, and alcohol intake are 77%, 42%, and 10%, respectively.[47] HPV also has been suggested as an etiology in both laryngeal and oral cavity verrucous carcinoma.[35,48,49]

The 2010 evidence-based clinical recommendations from the American Dental Association Council on Scientific Affairs pertaining to screening for oral SCCs suggest that clinicians continue to perform routine visual and tactile oral examinations in all patients, but especially in individuals who use tobacco and consume alcohol heavily. This corresponds to five or more drinks on a single occasion (generally within two hours or so) for men or four or more drinks on a single occasion for women.[50,51] In addition to oral screening, it also is important to include a complete social history, oral examination, and oral cancer risk assessment.[50]

Summary

Two U.S. presidents have been afflicted with head and neck cancer. The general public first became aware of smoking and alcohol consumption as risk factors for head and neck cancer during General Grant's time; additional risk factors have since been acknowledged.

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References

1. Heermans HW. Ulysses S. Grant. Br J Alcohol 1977;12(4):174-176.
2. Rorabaugh WJ. The alcoholic republic: An American tradition. New York: Oxford University Press; 1979:preface.
3. Carlson ER, Reddi SP. Oral cancer and United States presidents. J Oral Maxillofac Surg 2002; 60(2):190-193.
4. Nelson RB III. The final victory of General U.S. Grant. Cancer 1981;47(3):433-436.
5. New York Times. Ulysses S. Grant sinking into the grave. Dying slowly of cancer— Working calmly on his book in terrible pain. March 1, 1885.
6. Bickmore JT. Grant's cancer. Trans Sect Otolaryngol Am Acad Ophthalmol Otolaryngol 1975;80 (4 Pt 1):366-374.
7. Kaltzman A. Gift horses. *In:* Kaltman A. Cigars, whiskey & winning: Leadership lessons from General Ulysses S. Grant. New Jersey: Prentice Hall;1998:59.
8. Renehan A, Lowry JC. The oral tumours of two American presidents: What if they were alive today? J R Soc Med 1995;88(7):377-383.
9. Shrady GF. The surgical and pathological aspects of General Grant's case. Med Rec 1885;28:121-124.
10. Elliott GR. The microscopic examination of specimens removed from General Grant's throat. Med Rec 1885;28;289-290.
11. Folz BJ, Ferlito A, Weir N, Pratt LW, Rinaldo A, Werner JA. A historical review of head and neck cancer in celebrities. J Laryngol Otol 2007; 121(6):511-520.
12. Armed Forces Institute of Pathology. Department of Endocrine and Otorhinolaryngic–Head & Neck Pathology: A diagnosis of invasive SCC, moderately differentiated was made. Consultation report on contributor material. Washington DC. July 28, 2000.
13. Patel SG, Shah JP. TNM staging of cancers of the head and neck: Striving for uniformity among diversity. CA Cancer J Clin 2005;55(4):242-258.
14. Mendenhall WM, Stringer SP, Amdur RJ, Hinerman RW, Moore-Higgs GJ, Cassisi NJ. Is radiation therapy a preferred alternative to surgery for SCC of the base of tongue? J Clin Oncol 2000;18(1):35-42.
15. Walvekar RR, Li RJ, Gooding WE, Gibson MK, Heron D, Johnson JT, Ferris RL. Role of surgery in limited (T1-2, N0-1) cancers of the oropharynx. Larynogoscope 2008;118(12):2129-2134.
16. Gourin CG, Johnson JT. Surgical treatment of squamous cell carcinoma of the base of the tongue. Head Neck 2001;23(8):653-660.
17. Foote RL, Parsons JT, Mendenhall WM, Million RR, Cassisi NJ, Stringer SP. Is interstitial implantation essential for successful radiotherapeutic treatment of base of tongue carcinoma? Int J Radiat Oncol Biol Phys 1990;18(6):129-138.
18. Azizzadeh B, Enayati P, Chhetri D, Maghami E, Larian B, Blackwell KE, Abemayor E, Calcaterra TC. Long-term survival outcome in transhyoid resection of base of tongue SCC. Arch Otolaryngol Head Neck Surg 2002;128(9):1067-1070.
19. Cano ER, Lai SY, Caylakli F, Johnson JT, Ferris RL, Carrau RL, Snyderman CH, Gooding WE, Simenthal AA Jr, Myers EN. Management of squamous cell carcinoma of the base of the tongue with chemoradiation and brachytherapy. Head Neck 2009;31(11):1431-1438.
20. Cancer of the oropharynx (version v.2.2008). *In:* NCCN clinical practice guidelines in oncology. National Comprehensive Cancer Network, Inc.;2009. Available at: http://www.nccn.org/professionals/physician_gls/pdf/head-and-neck.pdf. Accessed May 15, 2010.
21. Weber PC, Myers EN, Johnson JT. Squamous cell carcinoma of the base of the tongue. Eur Arch Otorhinolaryngol 1993;250(2):63-68.
22. Petruzzelli GJ, Vandevender D. Reconstruction of the tongue base. Oper Tech Otolaryngol Head Neck Surg 2000;11(3):158-165.

23. Rieger JM, Zalmanowitz JG, Li SY, Sytsanko A, Harris J, Williams D, Seikaly H. Functional outcomes after surgical reconstruction of the base of tongue using the radial forearm free flap in patients with oropharyngeal carcinoma. Head Neck 2007;29(11);1024-1032.
24. Robson JS. The day a president disappeared. Dent His 2007;(44):31-43.
25. Morreels CL Jr. New historical information on the Cleveland operations. Surgery 1967;62(3): 542-551.
26. Deppisch LM. President Cleveland's secret operation: The effect of the office upon the care of the president. Pharos Alpha Omega Alpha Honor Med Soc 1995;58(3):11-16.
27. Brooks JJ, Enterline HT, Aponte G. The final diagnosis of President Cleveland's lesion. Trans Stud Coll Physicians Phila 1980;2(1):1-23.
28. Spiro RH. Verrucous carcinoma, then and now. Am J Surg 1998;176(5):393-397.
29. Keen WW. The surgical operations on President Cleveland in 1893. Philadelphia: George W. Jacobs & Co.;1917:1-52.
30. Aziz SR. The oral surgical operations of Grover Cleveland: A presidential cover-up. J Oral Maxillofac Surg 1995;53(9):1088-1090.
31. Ackerman LV. Verrucous carcinoma of the oral cavity. Surgery 1948;23(4):670-678.
32. Wang YP, Chen HM, Kuo RC, Yu CH, Sun A, Liu BY, Kuo YS, Chiang CP. Oral veruccous carcinoma hyperplasia: Histologic, classification, prognosis, and clinical implications. J Oral Path Med 2009;38(8):651-656. Epub 2009 Jul 27.
33. Arduino PG, Carrozzo M, Pagano M, Broccoletti R, Scully C, Gandolfo S. Immunohistochemical expression of basement membrane proteins of verrucous carcinoma of the oral mucosa. Clin Oral Investig 2010;14(3):297-302. Epub 2009 Jun 9.
34. Medina JE, Dichtel W, Luna MA. Verrucous-SCCs of the oral cavity: A clinicopathologic study of 104 cases. Arch Otolaryngol 1984;110(7):437-440.
35. Koch BB, Trask DK, Hoffman HT, Karnell LH, Robinson RA, Zhen W, Menck HR; Commission on Cancer, American College of Surgeons; American Cancer Society. National survey of head and neck verrucous carcinoma: Patterns of presentation, care and outcome. Cancer 2001; 92(1): 110-120.
36. Cooper PH. President Cleveland's palatal tumor. Arch Dermatol 1986;122(7):747-748.
37. Cutis TA, Beumer J. Restoration of acquired hard palate defects: Etiology, disability, and rehabilitation. *In:* Beumer J, Curtis TA, Marunick MT, eds. Maxillofacial rehabiliation: Prosthodontic and surgical considerations. St. Louis: Ishiyaku EuroAmerica, Inc.;1996:225.
38. Abee R. Cancer of the mouth: The case against tobacco. New York Med J 1915;102:1-2.
39. Wynder EL, Bross IJ, Feldman RM. A study of the etiological factors in cancer of the mouth. Cancer 1957;10(6):1300-1323.
40. Hobbs CG, Sterne JA, Bailey M, Heyderman RS, Birchall MA, Thomas SJ. Human papillomavirus and head and neck cancer: A systematic review and meta-analysis. Clin Otolaryngol 2006;31(4): 259-266.
41. Chaturvedi AK, Engels EA, Anderson WF, Gillison ML. Incidence trends for human papillomavirus-related and -unrelated oral squamous cell carcinomas in the United States. J Clin Oncol 2008; 26(4):612-619.
42. El-Mofty SK. Human papillomavirus (HPV) related carcinomas of the upper aerodigestive tract. Head Neck Pathol 2007;1(2):181-185.
43. Kreimer AR, Clifford GM, Boyle P, Franceschi S. Human papillomavirus types in head and neck SCCs worldwide: a systematic review. Cancer Epidemiol Biomarkers Prev 2005;14(2):467-475.
44. Gillison ML, Koch WM, Capone RB, Spafford M, Westra WH, Wu L, Zahurak ML, Daniel RW, Viglione M, Symer DE, Shah KV, Sidransky D. Evidence for a causal association between human papillomavirus and a subset of head and neck cancers. J Natl Cancer Inst 2000;92(9):709-720.
45. D'Souza G, Kreimer AR, Viscidi R, Pawlita M, Fakhry C, Koch WM, Westra, Gillison ML. Case-control study of human papillomavirus and oropharyngeal cancer. N Engl J Med 2007;356(19): 1944-1956.
46. Kramer D, Durham JS, Jackson S, Brookes J. Management of the neck in N0 squamous cell carcinoma of the oral cavity. J Otolaryngol 2001: 30(5):283-288.
47. Walvekar RR, Chaukar DA, Deshpande MS, Pai PS, Chaturvedi P, Kakade A, Kane SV, D'Cruz AK. Verrucous carcinoma of the oral cavity: A clinical and pathological study of 101 cases. Oral Oncol 2009;45(1):47-51. Epub 2008 Jul 11.
48. Kasperbauer JL, O'Halloran GL, Espy MJ, Smith TF, Lewis JE. Polymerase chain reaction (PCR) identification of human papillomavirus (HPV) DNA in verrucous carcinoma of the larynx. Laryngoscope 1993;103(4 Pt 1):416-420.
49. Fujita S, Senba M, Kumatori A, Hayashi T, Ikeda T, Toriyama K. Human papillomavirus infection in oral verrucous carcinoma: Genotyping analysis and inverse correlation with p53 expression. Pathobiology 2008;75(4):257-264. Epub 2008 Jun 26.
50. Rethman MP, Carpenter W, Cohen EE, Epstein J, Evans CA, Flaitz CM, Graham FJ, Hujoel PP, Kalmar JR, Koch WM, Lambert PM, Lingen MW, Oettmeier BW Jr, Patton LL, Perkins D, Reid BC, Sciubba JJ, Tomar SL, Wyatt AD Jr, Aravamudhan K, Frantsve-Hawley J, Cleveland JL, Meyer DM; American Dental Association Council on Scientific Affairs Expert Panel on Screening for Oral Squamous Cell Carcinomas. Evidence-based clinical recommendations regarding screening for oral squamous cell carcinomas. J Am Dent Assoc 2010;141(5):509-520.
51. National Institute of Alcohol Abuse and Alcoholism. NIAAA council approves definition of binge drinking. NIAAA Newsletter 2004;3:3.

Evaluation of four cementation strategies on the push-out bond strength between fiber post and root dentin

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This trial used push-out testing to evaluate four different fiber post cementation strategies. Specimens of bovine mandibular teeth were randomly allocated into four groups according to cementation strategies ($n = 10$): ScotchBond MultiPurpose and RelyX ARC (Group 1); AdheSE and Multilink Automix (Group 2); phosphoric acid and RelyX U100 (Group 3); and RelyX U100 (Group 4). Four slices from each specimen (2.0 mm thick) were obtained for the push-out test. All slices were analyzed for failure mode after testing.

A one-way ANOVA showed differences between the groups ($P = 0.002$). A Tukey test indicated that Group 1 had the highest bond strength values (13.96 ± 6.41 MPa). Groups 2 (6.58 ± 2.14 MPa), 3 (5.85 ± 2.57 MPa), and 4 (8.19 ± 2.28 MPa) had similar bond strengths, but all of them were lower than Group 1. A three-step total etching adhesive system, associated with a conventional resin cement, might be a good alternative for fiber post cementation.

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A key moment for dentistry was the advent of acid conditioning and dentin hybridization, which provided the ability for more conservative procedures with minimal intervention.[1] Another important moment for conservative dentistry occurred when Duret *et al* introduced fiber-reinforced composite posts.[2]

The use of prefabricated fiber posts for the restoration of endodontically treated teeth is a treatment option that preserves dental structure, reduces the risk of root fractures, and increases the coronal retention of restorative materials.[3,4] Clinical studies have demonstrated a higher percentage of success for teeth restored with reinforced composite resin posts than with other post systems.[5,6] However, post decementation remains the most frequently cited clinical failure; therefore, many cementation strategies have been tested recently *in vitro* to develop better luting agents and restorative techniques.[6-12]

Three-step total-etch-and-rinse adhesive systems have demonstrated favorable results as a post cementation strategy; however, this strategy requires a wet dentin substrate and is very difficult to control inside the root space.[8,10,12] Some authors have found better results for post cementation with two-step, self-adhesive systems than with the etch-and-rinse strategies.[13] This strategy does not require rinsing, further simplifying the procedure. On the other hand, the low demineralization potential of some adhesive systems in the presence of a smear layer could represent a decrease in bond strength.[14]

Self-adhesive cements are being studied in depth, especially because they do not require any procedures prior to cement application, reducing the technique's sensitivity.[8-11,13] Studies have found higher push-out bond strength values for post cementation with the self-adhesive cement RelyX U100 (3M ESPE), compared to conventional luting strategies.[8-10] These results could be associated with the favorable mechanical properties and the adhesion mechanism of this cement.[15-17]

A recent study indicated that self-adhesive cements have a low demineralization potential, leaving them to interact superficially with root dentin.[9] Therefore, acid etching prior to the application of a self-adhesive cement could remove the smear layer and increase the wettability and surface energy of the root dentin, improving the bond strength values.[18,19]

Therefore, taking into account the clinical approach for simplifying procedures, the present study aimed to evaluate the effect of four post cementation strategies on push-out bond strength values. The null hypotheses tested were that the various cementation strategies would generate similar push-out bond strength values, and that acid etching prior to application of a self-adhesive cement would not improve the push-out bond strength values between the cement and root dentin.

Materials and methods

Forty single-rooted bovine mandibular incisors were selected and standardized to a length of 16 mm by sectioning the crown and cervical root portions. The coronal diameters of the canals were measured using a digital caliper (Starrett 727, The L.S. Starrett Co.), and specimens with root canals presenting diameters larger than the diameter of the glass fiber post (2.0 mm, Whitepost DC No. 3, FGM) were discarded and replaced by specimens that met this requirement.

The root canals were prepared to a length of 12 mm using the preparation burs of the double-tapered glass fiber post system (Whitepost DC No. 3). The specimens were randomly divided into four groups according to the cementation strategy (Table 1). To ensure randomization, all specimens were numbered and four numerical sequences of 10 numbers were generated using Random Allocation software. The apical portions of all specimens were embedded with a chemically cured acrylic resin (Dencrilay, Dencril Produtos Odontologicos) in a plastic matrix using the technique described in 2009 by Amaral *et al.*[8]

Prior to cementation, all fiber posts were silanized according to the manufacturer's instructions (Prosil, FGM) and cemented as described in Table 1. A core buildup was not carried out, so specimens were stored in direct contact with 37°C water for seven days before push-out testing. All laboratory procedures were performed by one previously trained operator.

Table 1. Testing groups and cementation approaches.

Group	Adhesive system	Luting cement	Procedures
1	Three-step etch and rinse, self-cure (ScotchBond MultiPurpose, 3M ESPE)	Conventional resin cement (RelyX ARC, 3M ESPE)	a,b,c,d,e,f
2	Self-etching, two-step self-cure (AdheSE DC Activator, Ivoclar Vivadent Inc.)	Conventional resin cement (Multilink Automix, Ivoclar Vivadent Inc.)	g,c,d,e,f
3	None	Self-adhesive resin cement (RelyX U100, 3M ESPE)	a,b,c,e,f
4	None	Self-adhesive resin cement (RelyX U100, 3M ESPE)	e,f

a – Etching the root dentin with 37% phosphoric acid for 20 seconds. The tip of syringe reached whole post space into the root canal.

b – Washing with 10 mL of distilled water with a disposable syringe.

c – Removing the excess water/adhesive with No. 80 paper points.

d – Application of multi-step ScotchBond MultiPurpose Plus adhesive system (activator, primer, and catalyst, 3M ESPE), using microbrushes (Cavibrush, FGM)

e – Mixing the two cement pastes and applying them in the root canal with the Centrix system (Centrix, Inc.) using acudose points and the post.

f – Removing the excess cement and photocuring for 40 seconds (Radii-cal, SDI North America).

g – Application of self-etching adhesive AdheSE primer + (AdheSE Bond + AdheSE Acitvator).

Push-out bond strength test

The specimens were sectioned using a LabCut machine (Extec Corp.). The first cervical slice (approximately 1.0 mm) was discarded and four other sections per specimen (2.0 mm ± 0.4 mm) were obtained.

Each slice was positioned on a metallic device with a central opening (Ø = 3.0 mm) larger than the canal diameter, and force was applied directly on the fiber post in an apical/coronal direction.

The test was performed in a universal testing machine (EMIC Ltd.) at a speed of 1 mm/minute. The bond strength (σ) in MPa was obtained using the formula $\sigma = F/A$, where F = load for specimen rupture (N) and A = adhered area (mm^2). The adhered area (A) was calculated as described by Valandro *et al.*[20] The push-out test was conducted using a calibrated and blinded operator to avoid biased results. Specimens with cohesive fracture of the fiber post or dentin were excluded from the study because they did not correspond to the real push-out bond strength, thereby avoiding misinterpretation of the results.

Failure analysis

The type of failure was observed under a light microscope up to 200x magnification (Olympus America). Failures were classified as A1 (adhesive between dentin and cement), A2 (adhesive between post and cement), C1 (cohesive in cement), C2 (cohesive in post), C3 (cohesive in dentin), or M (adhesive failure associated with cohesive failure). Representative specimens were selected for analysis in a scanning electron microscope (JSM-6360 SEM, JEOL USA, Inc.).

Statistical analysis

Ten bond strength values from each group ($n = 10$) were used for statistical analysis (one-way ANOVA and a Tukey test, a = 0.05).

Results

No disk specimens were lost during sectioning. After push-out testing, 29 disk specimens were discarded

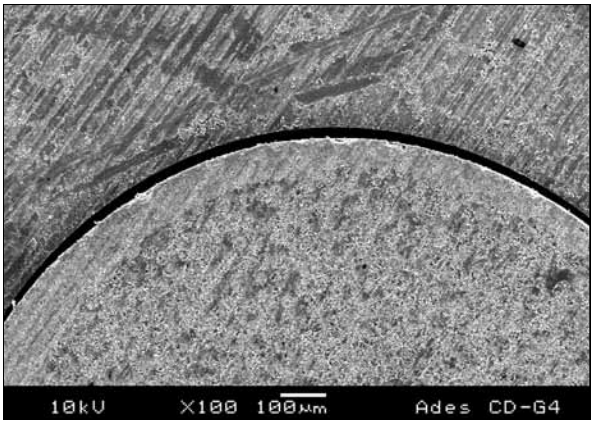

Fig. 1. Adhesive failure between cement and dentin (Group 4).

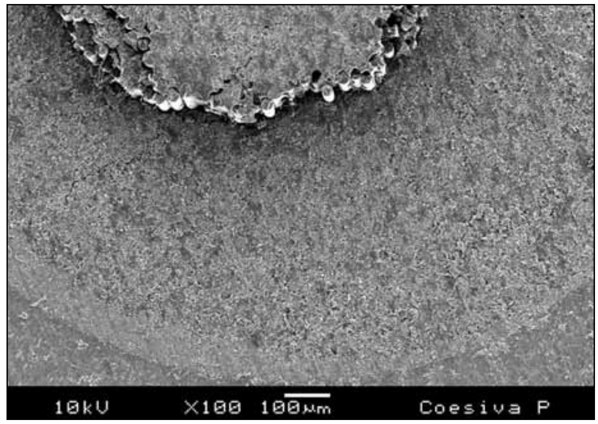

Fig. 2. Cohesive post failure (Group 1).

because they demonstrated cohesive fractures of the fiber post and 10 disks were discarded because they showed cohesive dentin fractures (Table 2). Three specimens from Group 1 were discarded because all disk specimens indicated cohesive post fractures. One-way ANOVA testing revealed that the factor "cement strategy" was statistically significant ($P = 0.0002$). A Tukey test highlighted differences among the experimental groups (Table 3). Adhesive failures between cement and dentin (Fig. 1) were predominant in Groups 2–4, while cohesive post failure (Fig. 2) was predominant in Group 1 (Table 2).

Discussion

The first hypothesis of the study was not accepted, because the strategy associating a three-step, total-etch adhesive system with a conventional, dual-cure resin cement had higher push-out bond strength values than the other strategies. These results were obtained with the push-out test which, in accordance with Goracci *et al*, has advantages for the evaluation of bond strengths between the fiber post and root dentin compared to the microtensile test.[21]

Some aspects could diminish bond strength values between a fiber post and root dentin. Bouillaguet *et al* demonstrated that the high C-factor of the root space (closed cavity) can reduce the bond strength when compared to an open cavity.[22] Mallmann *et al*, in comparing different adhesive systems, noted that a photocured adhesive system generated lower bond strength values compared to a chemically cured adhesive.[23] To control these factors, all strategies evaluated in the current study used chemically cured adhesive systems and were submitted to the same cavity design. Therefore, the differences observed between the groups are related to the cement properties and the ability of root dentin to create favorable patterns of hybridization with the adhesive systems.

Other studies have found better bond strength values for cementation strategies with total etch adhesive systems.[8,10,12] The low pH of phosphoric acid is responsible for etching the root dentin, removing the smear layer, and exposing the dentinal tubules.[9-14] Studies have indicated that this strategy generates better smear layer removal, adhesive penetration, and hybrid layer formation than strategies with two-step self-adhesive systems.[18] The more favorable results demonstrated by Group 1 also could be associated with the positive mechanical properties of RelyX ARC, such as flexural resistance and elastic modulus.[15,16]

The low push-out bond strength values found with the two-step self-adhesive system is in accordance with previous studies.[8-12] This result could be related to the inability of the adhesive to completely remove the smear layer, generating poor dentin demineralization and adhesive penetration.[9,14] This likely occurs due to a reaction between the acid monomers and the smear layer, which neutralizes the adhesive acidity.[24] In 2010, Skupien *et al* tested the micromorphological effects of five adhesive systems, including AdheSE.[25] According to those authors, AdheSE did not remove the smear layer, nor did it create a uniform hybrid layer.

Studies have demonstrated favorable results of self-adhesive cements compared to other fiber post cementation strategies.[8-10] These results could be associated with the positive values of flexural resistance and elastic modulus of the cement and the adhesion mechanism of the cement, which generates a strong union between the acidic monomers and the cement matrix, with a chemical interaction between the cement and hydroxyapatite in dentin.[16,17] However, studies have shown that self-adhesive cement cannot consistently dissolve the smear layer, affecting the ability of cement to penetrate into the root canal walls and creating gaps in the bonded interface.[9,11] This factor can be associated with the lowest push-out bond strength values found with self-adhesive cement compared to the three-step etch-and-rinse strategy.

For the adhesive factor of self-adhesive cement to be satisfactory, an interaction with the hydroxyapatite at the dentin surface is required.[17] Etching the dentin with phosphoric acid removes the smear layer and the dentin inorganic fillers affecting the chemical adhesion mechanism of self-adhesive cements.[14]

The failure analysis indicated a higher number of adhesive failures between cement and root dentin. These results are in accordance with the principal failure type observed in clinical studies, confirming that this interface is the most critical in the system. Group 1 was the only group that demonstrated a higher number of cohesive post failures. In accordance with Bitter *et al*, the bond strength to both dentin and post was greater than the stability of the post itself.[9]

Conclusion

The cementation strategy of associating a three-step etch-and-rinse adhesive system with a dual-cure resin cement could be a viable alternative for post cementation. Also, acid etching prior to application of a self-adhesive cement negatively affects push-out bond strength values.

Table 2. Analysis of failure mode and distribution between the groups.

	Type of failure					
Group	A1	A2	C1	C2	C3	M
1	14 (9%)	-	-	23 (14%)	3 (2%)	-
2	38 (24%)	-	-	1 (0.6%)	1 (0.6%)	-
3	38 (24%)	-	-	1 (0.6%)	1 (0.6%)	-
4	31 (19%)	-	-	5 (3.0%)	4 (2.5%)	-
Total	121 (76%)	-	-	30 (18%)	9 (6%)	-

A1 = adhesive between dentin and cement; A2 = adhesive between post and cement; C1 = cohesive in cement; C2 = cohesive in post; C3 = cohesive in dentin; M = adhesive failure assocated with cohesive failure.

Table 3. Push-out bond strength means and standard deviation of each group.

Group	Cementation strategy	Bond strength (MPa)
1	ScotchBond MultiPurpose and RelyX ARC	13.96 ± 6.41^{A}
2	AdheSE DC Activator and Multilink Automix	6.58 ± 2.14^{B}
3	Phosphoric acid and RelyX U100	5.85 ± 2.57^{B}
4	RelyX U100	8.19 ± 2.28^{B}

Note: Same superscript letters indicate similar statistical results.

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References

1. DeGrange M, Roulet JF. Minimally invasive restorations with bonding. Berlin: Quintessence Publishing Co. Inc.;1997.
2. Duret B, Reynaud M, Duret F. [New concept of coronoradicular reconstruction: The Composipost (1).] [Article in French.] Chir Dent Fr 1990; 60(540):131-141.
3. Lanza A, Aversa R, Rengo S, Apicella D, Apicella A. 3D FEA of cemented steel, glass and carbon posts in a maxillary incisor. Dent Mater 2005; 21(8):709-715.
4. Cheung W. A review of the management of endodonticaly treated teeth: Post, core and the final restoration. J Am Dent Assoc 2005;136(5):611-619.
5. Schmitter M, Rammelsberg P, Gabbert O, Ohlmann B. Influence of clinical baseline findings on the survival of 2 post systems: A randomized clinical trial. Int J Prosthodont 2007;20(2): 173-178.
6. Ferrari M, Cagidiaco MC, Goracci C, Vichi A, Mason PN, Radovic I, Tay F. Long-term retrospective study of the clinical performance of fiber posts. Am J Dent 2007;20(5):287-291.
7. Monticelli F, Grandini S, Goracci C, Ferrari M. Clinical behavior of translucent-fiber posts: A 2-year prospective study. Int J Prosthodont 2003;16(6):593-596.
8. Amaral M, Santini MF, Wandscher V, Amaral R, Valandro LF. An *in vitro* comparison of different cementation strategies on pull-out strength of a glass fiber post. Oper Dent 2009;34(4):443-445.

9. Bitter K, Paris S, Pfuertner C, Neumann K, Kielbassa AM. Morphological and bond strength evaluation of different resin cements to root dentin. Eur J Oral Sci 2009;117(3):326-333.
10. Radovic I, Mazzitelli C, Chief N, Ferrari M. Evaluation of the adhesion of fiber posts cemented using different adhesive approaches. Eur J Oral Sci 2008;116(6):557-563.
11. Goracci C, Sadek FT, Fabianelli A, Tay FR, Ferrari M. Evaluation on the adhesion of fiber posts to intraradicular dentin. Oper Dent 2005;30(5):627-635.
12. Valandro LF, Filho OD, Valera MC, de Araujo MA. The effect of adhesive systems on the pullout strength of a fiber glass reinforced composite post system in bovine teeth. J Adhes Dent 2005;7(4):331-336.
13. Zicari F, Coutinho E, De Munck J, Poitevin A, Scotti R, Naert I, Van Meerbeek B. Bonding effectiveness and sealing ability of fiber-post bonding. Dent Mater 2008;24(7):967-977.
14. Santini A, Miletic V. Quantitative micro-Raman assessment of dentine demineralization, adhesive penetration, and degree of conversion of three dentine bonding systems. Eur J Oral Sci 2008;116(2):177-183.
15. Braga RR, Cesar PF, Gonzaga CC. Mechanical properties of resin cements with different activation modes. J Oral Rehabil 2002;29(3):257-262.
16. Saskalauskaite E, Tam LE, McComb D. Flexural strength, elastic modulus, and pH profile of self-etch resin luting cements. J Prosthodont 2008;17(4):262-268. Epub 2007 Dec 17.
17. Radovic I, Monticelli F, Goracci C, Vulicevic ZR, Ferrari M. Self-adhesive resin cements: A literature review. J Adhes Dent 2008;10(4):251-258.
18. Rosales JI, Marshall GW, Marshall SJ, Watanabe LG, Toledano M, Cabrerizo MA, Osorio R. Acid etching and hydration influence on dentin roughness and wetability. J Dent Res 1999;78(9):1554-1559.
19. Toledano M, Osorio R, Perdigao J, Rosales JI Thompson JY, Cabrerizo-Vilchez MA. Effect of acid etching and collagen removal on dentin wettability and roughness. J Biomed Mater Res 1999;47(2):198-203.
20. Valandro LF, Baldissara P, Galhano GA, Melo RM, Mallmann A, Scotti R, Bottino MA. Effect of mechanical cycling on the push-out bond strength of fiber posts adhesively bonded to human root dentin. Oper Dent 2007;32(6):579-588.
21. Goracci C, Tavares AU, Fabianelli A, Monticelli F, Raffaelli O, Cardoso PC, Tay F, Ferrari M. The adhesion between fiber posts and canal walls: Comparison between microtensile and push-out bond strength measurements. Eur J Oral Sci 2004;112(4):353-361.
22. Bouillaguet S, Troesch S, Wataha JC, Krejci I, Meyer JM, Pashley DH. Microtensile bond strength between adhesive cements and root canal dentin. Dent Mater 2003;19(3):199-205.
23. Mallmann A, Jacques LB, Valandro LF, Mathias P, Muench A. Microtensile bond strength of light- and self-cured adhesive systems to intraradicular dentin using a translucent fiber post. Oper Dent 2005;30(4):500-506.
24. Watanabe I, Nakabayashi N, Pashley DH. Bonding to ground dentin by a phenyl-P self-etching primer. J Dent Res 1994;73(6):1212-1220.
25. Skupien JA, Susin AH, Angst PD, Anesi R, Machado P, Bortolotto T, Krejci I. Micromorphological effects and the thickness of the hybrid layer—A comparison of current adhesive systems. J Adhes Dent 2010;12(6):435-442. doi: 10.3290/j.jad.a18242.

Manufacturers

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Intraoral chemical burn from use of 3% hydrogen peroxide

Arash M. Rostami, DDS ▪ John K. Brooks, DDS

Injudicious use of over-the-counter 3% hydrogen peroxide, a relatively potent oxidative agent, can result in a chemical burn to the oral mucosa. This article describes a patient who rinsed with 3% hydrogen peroxide for periods of more than two minutes as a self-prescribed remedy for oral discomfort following seafood ingestion. Subsequently, the patient experienced pain and extensive chemical burns of the sublingual and buccal mucosa and gingiva. In addition, the buccal mucosa underwent necrosis. Prolonged oral mucosal contact with 3% hydrogen peroxide is ill-advised.

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A diverse array of professional dental health care products is employed for plaque control, caries prevention, promotion of wound healing following trauma or oral surgery, oral lesion resolution, halitosis, denture retention, and xerostomia. Lack of mucosal damage and unwarranted systemic side effects are paramount to the use of any of these intraoral preparations.

Various dental restorative and endodontic products and materials have been implicated with oral soft tissue chemical burns; these include hydrochloric and hydrofluoric acid etchant agents, tooth whitening agents, dentin bonding agents, cavity varnish, denture cleansers, calcium hydroxide, formocresol, silver nitrate, phenol, and sodium hypochlorite.[1,2] Use of topical toothache formulations, detergent-based and "tartar control" toothpastes, and excessive alcohol-based mouthwashes can lead to oral sloughing.[3-6] Oral soft tissue burns from exothermic reactions have occurred following the use of dental interim restorative materials and denture base liners.[7,8]

Oral mucosal ulcerations have also been reported with chewing cinnamon-flavored foodstuffs or chewing gum and the topical application of crushed garlic when used as a homeopathic remedy for toothache relief.[9,10] Furthermore, oral chemical injury can be attributed to direct contact with aspirin and alendronate.[11,12] Illicit use of the recreational drugs cocaine and amphetamines has been associated with chemical burns of the mouth and upper airway.[2,13] Severe chemical burns to the oral mucosa, consequent to accidental or self-destructive behavior, have been reported with the intake of lye, sulfuric acid, gasoline, and battery acid.[2,14] Other lookalike lesions that resemble chemically induced ulcerations are traumatic ulcers, factitious injuries (for example, fingernail scratches), and morsicatio (a chronic habit of biting the oral mucosa). Thermal burns attributed to cooking utensils and foodstuffs can mimic chemical burns.[14]

Occasionally, case reports have documented adverse intraoral sequelae from self-administered agents, such as over-the-counter (OTC) 3% hydrogen peroxide.[15-19] Direct tissue contact, particularly with prolonged exposure, can produce sloughing or chemical burns, leading to coagulative necrosis to the mucosal lining of the oral cavity, esophagus, pharynx, and stomach, often accompanied by pain. To extend the knowledge of the deleterious effects of 3% hydrogen peroxide, this article provides the clinical outcome of extended oral contact with this seemingly innocuous irrigant.

Case report

A 30-year-old man sought urgent care at a dental office for what he termed an oral "infection" of one week. The patient reported experiencing discomfort under his tongue shortly after ingesting seafood. The etiology was unclear, although the patient believed it to be an allergic reaction to the seafood. For relief, the patient admitted rinsing his mouth with OTC 3% hydrogen peroxide and Listerine mouthwash (Johnson & Johnson Healthcare Products Division of McNeil-PPC, Inc.) along with retaining these solutions in his mouth for periods of two minutes or longer. He also applied cotton swabs saturated with hydrogen peroxide to the region and to the left buccal mucosa. The patient had recently undergone a physical assessment for his employment with no significant findings, and he was not taking any medications.

Fig. 1. Sloughing of the sublingual mucosa attributed to 3% hydrogen peroxide misuse.

Fig. 2. Chemical necrosis and sloughing of the buccal mucosa. Interdental papilla of the canine and lateral incisor exhibited mild erythema.

Fig. 3. One-week follow-up demonstrates significant clinical improvement.

The clinical examination was significant for moderate to severe swelling of the lower left lip. Intraorally, extensive sloughing was evident sublingually (Fig. 1) and the left buccal mucosa demonstrated a chemical burn with significant necrosis (Fig. 2). Mild erythema was also noted on the labial gingiva of the mandibular left canine and left lateral incisor. The patient was afebrile and without lymphadenopathy, and there was no Nikolsky sign.

The patient was advised to discontinue using hydrogen peroxide and switch to saline rinses. At a one-week follow-up appointment, significant clinical improvement was seen (Fig. 3). Although the patient chose not to be seen again for further evaluation, he was reached by telephone and indicated amelioration of the lip swelling and continued reduction in oral pain.

Discussion

Three percent hydrogen peroxide is a household product that is often used for bleaching and disinfection and as an antiseptic cleanser. There appears to be an assumed belief in the general population that OTC health care products can be used safely and without fear of toxicity.[20] In light of recent economic conditions and lack of access to medical care, patients are resorting to a greater reliance on readily available and usually inexpensive medicaments. As a consequence, there has been a reported increase of untoward side effects resulting from misuse of these products.[21] Historically, patients have self-administered 3% hydrogen peroxide for oral use as a mouthwash for halitosis or gingivitis, treatment of dental infection or aphthous ulceration, and for relief of mouth pain.[15-19]

Chemically, hydrogen peroxide is regarded as an oxidizing agent and can be cytotoxic, even in diluted concentrations as low as 1%.[22] Soft tissue damage can result from corrosive injury, oxygen gas formation, and lipid peroxidation.[23] Typical hydrogen peroxide-induced oral mucosal lesions appear as a whitish epithelial sloughing with focal areas of erythema, ulceration, and necrosis.

A review of a recent *Material safety data sheet* on 3% hydrogen peroxide indicated that "Large oral doses may cause irritation and blistering to the mouth, throat, and abdomen. May also cause abdominal pain, vomiting, and diarrhea."[24]

Ingestion of 35% hydrogen peroxide can lead to serious medical complications, including permanent neurological impairment, hemorrhagic gastritis, tachycardia, laryngospasm, respiratory arrest, gas emboli, convulsions, cerebral infarction, coma, and even death.[23]

The acquisition of a comprehensive medical and dental history is a requisite for rendering the diagnosis of lesions with an undefined etiology. The patient must provide a complete inventory of all oral hygiene products, homeopathic regimens, and current prescription and OTC medications. Moreover, an extensive list of pathologic disorders may be similar in appearance to hydrogen peroxide-induced oral lesions and should include necrotizing ulcerative gingivitis, primary herpetic gingivostomatitis, erythema multiforme, candidiasis, leukoedema, leukoplakia, hereditary benign intraepithelial dyskeratosis, white sponge nevus, pachyonychia congenita, dyskeratosis congenita, pemphigus, paraneoplastic pemphigus, mucous membrane pemphigoid, bullous pemphigoid, lichen planus, aphthous ulcers, systemic lupus erythematosus, chronic ulcerative stomatitis, graft-versus-host disease, traumatic ulcers, factitious injuries (for example, fingernail scratches), and morsicatio (a chronic habit of biting the oral mucosa).

Painful oral chemical burns can be managed with the application of topical anesthetic agents, such as 20% benzocaine gel, either alone or mixed with a methylcellulose adhesive, warm saline rinses, swishing with a 50:50 mixture of diphenhydramine liquid and magnesium hydroxide, or viscous xylocaine. Also, affected patients should be urged to maintain a soft, bland diet and re-examined weekly until oral healing is complete. Systemic analgesics may be needed for severe burns. Rarely, antibiotics may be necessary with the onset of secondary infection, submucosal necrosis, or bone exposure.[16]

Summary

Patients should be informed about the caustic properties of 3% hydrogen peroxide and told that it is not intended for prolonged contact with oral tissues. If 3% hydrogen peroxide is to be used as an oral irrigant, a 50% dilution with water is recommended, and the site should be flushed immediately with water or saline. When suspected oral hydrogen peroxide chemical burns exhibit an atypical presentation or persist without clinical improvement, a histopathologic assessment should be performed.

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References

1. Harris JH. Soft-tissue burns from a dentin bonding agent. Gen Dent 1991;39(5):350-351.
2. Gilvetti C, Porter SR, Fedele S. Traumatic chemical oral ulceration: A case report and review of the literature. Br Dent J 2010;208(7):297-300.
3. Antunes LA, Kuchler EC, de Andrade Risso P, Maia LC. Oral chemical burns caused by self-medication in a child: Case report. J Burn Care Res 2009;30(4):740-743.
4. Kuttan NA, Narayana N, Moghadam BK. Desquamative stomatitis associated with routine use of oral health care products. Gen Dent 2001;49(6):596-602.
5. Kowitz G, Jacobson J, Meng Z, Lucatorto F. The effects of tartar-control toothpaste on the oral soft tissues. Oral Surg Oral Med Oral Pathol 1990;70(4):529-536.
6. Moghadam BK, Gier R, Thurlow T. Extensive oral mucosal ulcerations caused by misuse of a commercial mouthwash. Cutis 1999;64(2):131-134.
7. Weaver RE, Goebel WM. Reactions to acrylic resin dental prostheses. J Prosthet Dent 1980; 43(2):138-142.
8. Driscoll CF, Woolsey G, Ferguson WM. Comparison of exothermic release during polymerization of four materials used to fabricate interim restorations. J Prosthet Dent 1991;65(4):504-506.
9. Siqueira AS, Santos CC, Cristino MR, Silva DC, Pinheiro MG, Pinheiro JJ. Intraoral contact mucositis induced by cinnamon-flavored chewing gum—A case report. Quintessence Int 2009; 40(9):719-721.
10. Bagga S, Thomas BS, Bhat M. Garlic burn as self-inflicted mucosal injury—A case report and review of the literature. Quintessence Int 2008; 39(6):491-494.
11. Maron FS. Mucosal burn resulting from chewable aspirin: Report of case. J Am Dent Assoc 1989;119(2):279-280.
12. Krasagakis K, Kruger-Krasagakis S, Ioannidou D, Tosca A. Chronic erosive and ulcerative oral lesions caused by incorrect administration of alendronate. J Am Acad Dermatol 2004;50(4): 651-652.
13. Smith JC, Kacker A, Anand VK. Midline nasal and hard palate destruction in cocaine abusers and cocaine's role in rhinologic practice. Ear Nose Throat J 2002;81(3):172-177.
14. Baruchin AM, Lustig JP, Nahlieli O, Neder A. Burns of the oral mucosa. Report of 6 cases. J Craniomaxillofac Surg 1991;19(2):94-96.
15. Rees TD, Orth CF. Oral ulcerations with use of hydrogen peroxide. J Periodontol 1986;57(11): 689-692.
16. Flaitz CM. Chemical burn of the labial mucosa and gingiva. Am J Dent 2001;14(2):115-116.
17. Fantasia JE, Damm DD. White mucosa. Chemical burn. Gen Dent 2001;49(3):265,324.
18. Rawal SY, Claman LJ, Kalmar JR, Tatakis DN. Traumatic lesions of the gingiva: A case series. J Periodontol 2004;75(5):762-769.
19. Shetty K. Hydrogen peroxide burn of the oral mucosa. Ann Pharmacother 2006;40(2):351.
20. Ferner R, Beard K. Over the counter medicines: Proceed with caution. BMJ 2008;336(7646): 694-696.
21. Rolita L, Freedman M. Over-the-counter medication use in older adults. J Gerontol Nurs 2008; 34(4):8-17.
22. Physical and chemical burns. *In:* Neville BW, Damm DD, Allen CW, Bouquot JE. Oral and maxillofacial pathology, ed 3. St. Louis: Saunders/ Elsevier;2009;292.
23. Watt BE, Proudfoot AT, Vale JA. Hydrogen peroxide poisoning. Toxicol Rev 2004;23(1):51-57.
24. Material safety data sheet. Hydrogen peroxide 3%. Available at: http://www.mallchem.com/ msds/englishhtml/h4073.htm. Accessed August 8, 2011.

Manufacturers

Johnson & Johnson Healthcare Products Division of McNeil-PPC, Inc., Skillman, NJ
888.222.0182, www.listerine.com

Isolated gingival enlargement

Douglas D. Damm, DDS
(Case courtesy of Dr. Neal Lemmerman, West Chester, OH)

A 47-year-old woman presented with an asymptomatic enlargement of the alveolar ridge facial to the maxillary right premolar and first molar (Fig. 1). Panoramic and periapical radiographs were within normal limits. Periodontal probing and tooth vitality testing discovered no associated inflammatory focus. Palpation revealed a firm soft tissue mass. An excisional biopsy was performed (Fig. 2).

Which of the following is the most appropriate diagnosis?

A. Neurilemoma
B. Neurofibroma
C. Peripheral odontogenic fibroma
D. Peripheral odontogenic myxoma

Diagnosis is on page 509.

Fig. 1. Mirror view of an asymptomatic enlargement of the alveolar ridge facial to the maxillary right premolar and first molar.

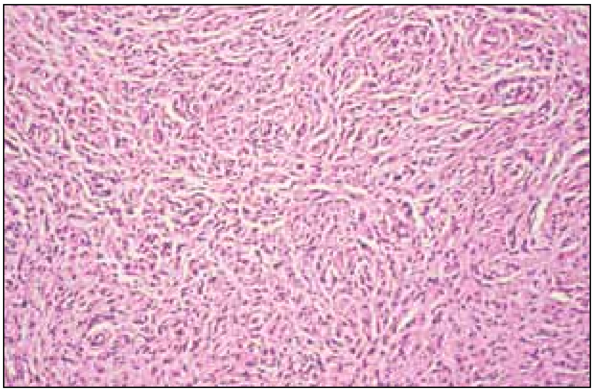

Fig. 2. Hypercellular fibrous connective tissue containing numerous spindle-shaped and wavy mesodermal cells arranged in a swirling pattern.

Postoperative lip swelling

(Case courtesy of Dr. Ted Raybould, Lexington, KY)

A 17-year-old girl presented with extreme enlargement of her lower lip, which had arisen the previous day. Two days earlier, all four of her third molars had been surgically removed under IV sedation with midazolam and fentanyl. Lidocaine with epinephrine provided the local anesthesia. Oxycodone/acetaminophen was prescribed for postoperative pain. A review of the medical history revealed that the patient was under a cardiologist's care, which included a prescription for lisinopril.

Fig. 1. Extreme enlargement of the lower lip.

Which of the following is the most likely diagnosis?

A. Angioedema related to an ACE inhibitor
B. Cheilitis granulomatosa
C. Hereditary angioedema
D. Melkersson Rosenthal syndrome

Diagnosis is on page 509.

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Oral Diagnosis

Isolated gingival enlargement

Diagnosis:

B. Neurofibroma.

The histopathologic specimen revealed a mass of hypercellular fibrous connective tissue containing numerous spindle-shaped and wavy mesodermal cells arranged in a swirling pattern. Upon immunoperoxidase evaluation, the spindle cells were reactive with the neural marker, S-100 protein.

Although most neurofibromas are isolated and not associated with a syndrome, the possibility of neurofibromatosis should be considered. Local surgical excision is appropriate therapy, and recurrences are rare. Malignant transformation of isolated neurofibromas is possible but extremely uncommon.

Bibliography

1. Regezi JA, Sciubba JJ, Jordan RCK. Oral pathology. Clinical pathologic correlations, ed. 5. St. Louis: Saunders/Elsevier;2008:170-172.

Postoperative lip swelling

Diagnosis:

A. Angioedema related to an ACE inhibitor.

Since this association was documented recently in *General Dentistry,* the case should have been straightforward. Still, the definitive diagnosis of patients with angioedema can be challenging. Three major causes are seen: The most widely known pattern occurs secondary to allergic reactions with histamine release. Less-publicized triggers include inhibition of bradykinin degradation by ACE inhibitors and activation of the complement pathway. Angioedema secondary to activation of complement can be hereditary or acquired by a variety of pathoses, such as lymphoproliferative diseases or autoimmune disorders.

In patients who have angioedema related to ACE inhibitors or complement activation, the triggering event frequently is local physical manipulation, such as a dental procedure. The attack can occur after many years of uncomplicated use of an ACE inhibitor. In individuals with hereditary angioedema, the attacks triggered by a dental procedure can be delayed, with reports of patients dying in their sleep two days after a dental surgical procedure.

In contrast to attacks related to an allergy, angioedema secondary to use of an ACE inhibitor is not IgE-mediated and does not respond to antihistamines, epinephrine, or corticosteroids. Affected patients must be kept under close observation until the soft tissue swellings begin to recede. If the airway becomes compromised, it must be maintained mechanically.

Bibliography

1. McFarland KK, Fung EY. Enalapril-induced angioedema: A dental concern. Gen Dent 2011;59(2):148-150.
2. Bork K, Barnstedt SE. Laryngeal edema and death from asphyxiation after tooth extraction in four patients with hereditary angioedema. J Am Dent Assoc 2003;134(8):1088-1094.
3. Neville BW, Damm DD, Allen CM, Bouquot JE. Oral and maxillofacial pathology, ed. 3. St. Louis: Saunders/Elsevier;2009:356-358.

Self-Instruction

Exercise No. 273
November/December 2010, p. 493

1. D	2. A	3. B	4. B
5. C	6. B	7. D	8. B
9. B	10. C	11. A	12. B
13. C	14. A	15. D	

Exercise No. 274
November/December 2010, p. 503

1. A	2. B	3. C	4. C
5. B	6. B	7. D	8. A
9. D	10. A	11. D	12. C
13. B	14. D	15. C	

Exercise No. 275
November/December 2010, p. 518

1. D	2. C	3. B	4. B
5. A	6. D	7. A	8. B
9. B	10. C	11. C	12. A
13. B	14. A	15. C	

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4. A B C D	4. A B C D	4. A B C D
5. A B C D	5. A B C D	5. A B C D
6. A B C D	6. A B C D	6. A B C D
7. A B C D	7. A B C D	7. A B C D
8. A B C D	8. A B C D	8. A B C D
9. A B C D	9. A B C D	9. A B C D
10. A B C D	10. A B C D	10. A B C D
11. A B C D	11. A B C D	11. A B C D
12. A B C D	12. A B C D	12. A B C D
13. A B C D	13. A B C D	13. A B C D
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3. A B C D	3. A B C D	3. A B C D
4. A B C D	4. A B C D	4. A B C D
5. A B C D	5. A B C D	5. A B C D
6. A B C D	6. A B C D	6. A B C D
7. A B C D	7. A B C D	7. A B C D
8. A B C D	8. A B C D	8. A B C D
9. A B C D	9. A B C D	9. A B C D
10. A B C D	10. A B C D	10. A B C D
11. A B C D	11. A B C D	11. A B C D
12. A B C D	12. A B C D	12. A B C D
13. A B C D	13. A B C D	13. A B C D
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Diametral tensile strength of four composite resin core materials with and without centered fiber dowels

Cornel H. Driessen, BChD, BChD (Hons), MSc, PhD ▪ Donatta Y-J. Ji, DDS ▪ Amin S. Rizkalla, PhD, PEng
Gildo C. Santos Jr., DDS, MSc, PhD

This study evaluated the diametral tensile strength of composite resin core materials with and without fiber dowels. Eight groups were established ($n = 20$), four with composite resins and four with fiber dowels. Samples were tested using a universal testing machine and evaluated using scanning electron microscopy. One-way ANOVA and a Tukey B-rank order test ($P = 0.05$) indicated that the tensile values of two of the four composite resins decreased significantly when their matching fiber dowels were introduced.

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The clinical procedure to restore lost structure for endodontically treated teeth, using a directly placed composite resin as core material to retain a fixed prosthesis, such as a crown, has emerged as the treatment method of choice since the early 1990s.[1,2] Clinicians also have advocated the use of prefabricated dowels to provide retention for the core material as an alternative to laboratory-fabricated cast dowels and cores.[1,3,4] The intraradicular cementation of fiber dowels as part of a chairside foundation for crown placement for an endodontically treated tooth has been shown to be more successful in many situations when compared to the cast-metal dowel and core method.[5,6]

The primary disadvantage of cast dowels is the high modulus of elasticity of the metal, which exceeds the modulus of elasticity of the dentin by a factor of 8–15. This difference results in a high incidence of root fracture due to a high-stress concentration at the tooth/dowel interface. Moreover, cast dowels require additional clinical visits and more extensive removal of dental structure, and they can stain the adjacent root area.[6] A similar staining problem can occur when using prefabricated metal alloy dowels.[7,8] Clinical treatment using restorative materials that can imitate or simulate the physical properties of tooth structure appears to be the preferred approach.[3,6,9-11]

The chairside method of direct replacement of lost coronal tooth structure can be easier to perform and involves less time and cost when compared to conventional indirect restorations.[1,3,7,10,12] Material selection and material handling can be a challenge for the clinician. Three factors must be considered in clinical treatment of endodontically treated teeth and research protocols for core foundation: the type of composite resin used as a core material; the fiber dowel, if needed; and the type of tooth structure involved. The primary issue is the bonding integrity between materials and between material and tooth structure.[13-17] Recent research has made material selection more complex by demonstrating that the use of dowels for core retention in endodontically treated teeth does not increase the tensile strength compared to tooth restoration with core material only.[2,16,18,19]

There have been a number of published studies with varying results that cannot be compared because of differences among the methods involved in the evaluation of chairside core foundation systems. For example, although it has been shown that some surface-treated titanium alloy and zirconium oxide dowels increased diametral tensile strength (DTS) values, other research has demonstrated the opposite, that there is no significant effect on DTS values.[13,14,20] Apart from the differences among testing methods, some manufacturers recommend surface treatment of dowels, with subsequent changes on the physico-chemical nature to create stronger bonds.[3] The interface integrity between the fiber dowel and composite resin core material can be weakened if the dowel surface is not treated to increase bond strength.[14,15,21-24]

The purpose of this study was to evaluate the DTS values of four composite resin core foundation materials with and without their

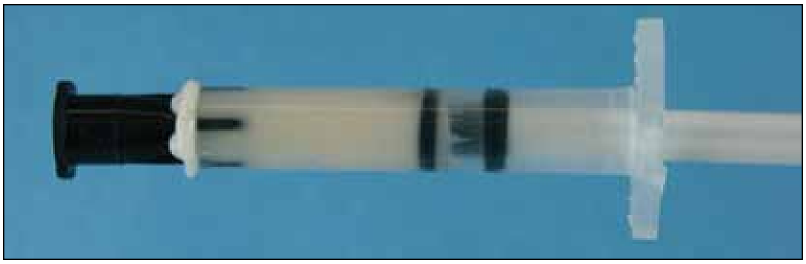


Fig. 1. Plunger application to ensure composite resin without voids around fiber dowel prior to visible light polymerization.

Fig. 2. Disc sample mounted in the testing device assembled for DTS testing.

Table 1. Material names, abbreviated group identifications, and manufacturers.

Group	Brand name	Group abbreviation for study	Manufacturer
1	Core Paste XP	XP	Den-Mat Holdings, LLC
2	PermaFlo DC	PF	Ultradent Products, Inc.
3	StarFill 2B	SF	Danville Materials
4	ParaCore Automix	PC	Coltene/Whaledent, Inc.
5	Core-Post	XPC	Den-Mat Holdings, LLC
6	UniCore Post	PFU	Ultradent Products, Inc.
7	IcePost	SFI	Danville Materials
8	ParaPost Fiber Lux	PCF	Coltene/Whaledent, Inc.

corresponding fiber dowels, and to evaluate, using scanning electron microscopy (SEM), the type of failure that occurs at the interface of fiber dowel and composite resin. The null hypothesis was that there is no difference in DTS values between composite resin core materials with and without fiber dowels.

Materials and methods

Eight groups (*n* = 20) of disc-shaped samples measuring 5.0 mm x 2.6 mm were prepared. The first four groups were prepared using four different composite resin materials (Core Paste XP, PermaFlo DC, StarFill 2B, and ParaCore Automix) (Table 1). The other four groups were fabricated by adding to the center of each composite resin sample the corresponding recommended fiber dowel (Core-Post, UniCore Post, IcePost, and ParaPost Fiber Lux) (Table 1). A syringe with an internal diameter (Ø) of 5.0 mm (BD) was used as a mold to fabricate the sample material rods.

All materials were handled according to the manufacturers' instructions. The composite resin rods were placed in a visible light-polymerizing (VLP) chamber (Heraeus Kulzer, Inc.) at 1,600 mW/cm^2 for 60 seconds. For groups 5–8, a 22 gauge multipurpose tip (Patterson Dental/Dentaire Canada Inc.) was modified to centralize the fiber dowel prior to covering it with composite resin. For the purpose of standardization, groups 5–8 contained dowels with diameters closest to 1.2 mm Ø of their parallel shank. These groups were subjected to the same VLP process as groups 1–4 (Fig. 1). All polymerized materials were marked for the proper identification, submerged in double-distilled, deionized water for 48 hours within syringes, and incubated at 37°C.

The rods were sectioned while the material was in the syringes (five discs per syringe) using a slow-rotating, diamond wafer blade (Struers Minitom, Struers Inc.) with copious amounts of water to produce the 20 sample discs for each group (2.6 mm thick). Only discs that contained the parallel shank section of the dowels were used; additional filled syringes were needed to produce the necessary sample quantity for each group.

The sample discs were removed from the cut syringe mold sections and evaluated for quality under 20x magnification using a stereo microscope (StereoZoom 7, Bausch & Lomb). Each sample was measured for thickness and diameter (±0.001) using a Starrett digital micrometer (The L.S. Starrett Co.) before being stored in deionized water for another 12 days prior to DTS testing. Cross-sectional area and thickness of each sample were noted before DTS testing.

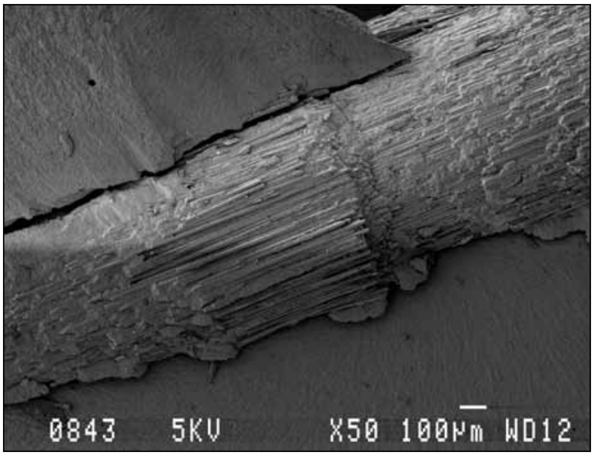


Fig. 3. Cohesive failure illustrating some fiber particles torn from the dowel surface (50x magnification).

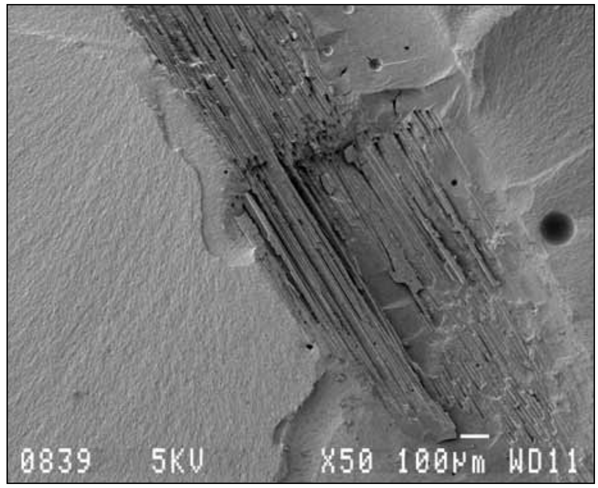
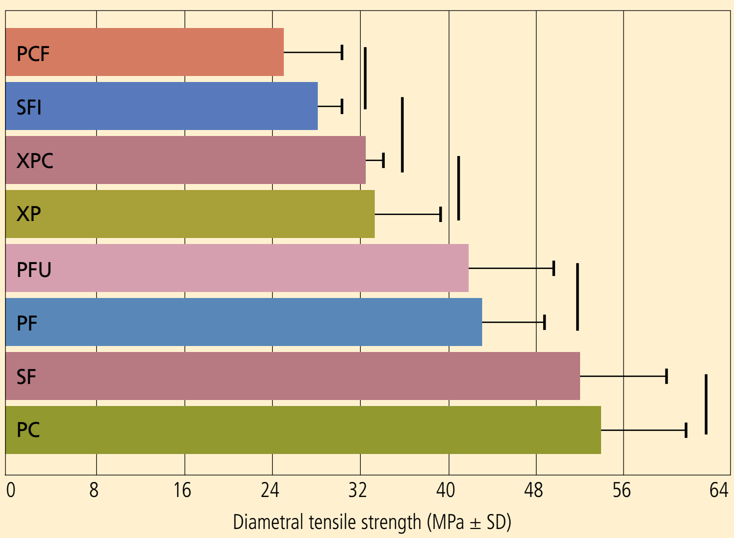


Fig. 4. Adhesion/cohesion failure (50x magnification).

Chart 1. Mean DTS values and standard deviations (MPa) shown for all groups. Solid lines indicate groups that are not significantly different ($P \geq 0.05$).



Disc-shaped samples were placed into a testing device (Bencor Multi-T, Danville Materials) to allow for easy repeatable handling of delicate specimens assembled in compression mode (Fig. 2). DTS testing was conducted using a universal testing machine (Model 3345, Instron Corp.) at a crosshead speed of 1.0 mm/minute (at 50% humidity and 22°C) until failure. DTS for each sample was calculated using the following equation:

$$\sigma_x = \frac{2P}{\pi DT}$$

where σ_x is DTS (MPa), P is the force (N), D is the specimen diameter (mm), and T is the specimen thickness (mm).[25]

Statistical analysis of the data was conducted using one-way ANOVA and Tukey-B rank order tests at $P = 0.05$. Fractured samples were retained in identified containers and SEM observation was performed to determine whether the failure was cohesive or adhesive. The fragments were placed on holders with the aid of adhesive double-faced ribbon (Shintron, Shinto Paint Co., Ltd.) and coated with a thin film of platinum (6 µm thick). The samples then were placed in a scanning electron microscope (Model S-2500, Hitachi High Technologies America, Inc.) with voltage of acceleration of 10 kV, and images of the fragments with fractured surfaces were observed under 50X magnification.

Results

The DTS values for all materials tested are displayed in Chart 1. A Tukey rank order test separated the eight different materials into five levels at $P < 0.05$. The DTS value for PCF was significantly reduced from that for PC by 54% ($P < 0.05$). The DTS value for SFI was significantly reduced from that for SF by 46%. There was no significant difference between the DTS value for PF and that for PFU ($P > 0.05$). Similarly, the DTS value for XP was not significantly different from that for XPC ($P > 0.05$), which suggests stronger interfacial bonds between cores and dowels of these two groups.

With respect to the SEM image findings, PCF and SFI had images that demonstrated cohesive failures (Fig. 3), while PFU and XPC demonstrated mixed failure (Fig. 4).

Discussion

This *in vitro* study was designed to evaluate the mechanical properties of composite resin materials when combined with fiber dowels. The diametral compression test is an alternative to direct tensile testing suitable for brittle materials.[9,25] The tensile stress was generated at the circular area of these disk samples, resulting in tension at the dowel/resin interface.

Thermal cycling was not applied to the samples. According to Purton *et al,* thermal cycling should be afforded less emphasis in tests on the retention of root canal dowels cemented with resin cements.[19] In another study investigating the effects of pretreatment on bond strength between resin cements and various dowels, including prefabricated glass fiber dowels and an IPN post (Stick Tech), it was found that thermal cycling had no significant influence.[15]

The results for two of the resin fiber dowels did not support the null hypothesis. This could be attributed to a weak interfacial bond between the resin and the dowel. This result is in line with other recent studies in which the fiber dowel acts as a weakening factor, resulting in the reduction of the mechanical properties of composite resin core foundation materials.[8,9,14,19] The outcomes of numerous studies have emphasized the importance of a proper bond integrity between the composite resin and the fiber dowel.[13,18,21,23,26]

The prominent reduction in DTS value for the composite resin materials used with PC (54.08 MPa) and PCF (25.04 MPa) could be explained by the fact that the manufacturer's instructions do not suggest the use of surface treatment to the fiber dowel prior to the addition of composite resin. This could explain the early failures and lowered DTS values observed. Similar results were obtained from samples of SF (52.18 MPa) and SFI (28.27 MPa), although Prelude adhesive was suggested for application as a surface adhesive prior to bonding the composite resin to the fiber dowel. In both cases, the DTS values of the composite/dowel combination were significantly lower than those of their core materials ($P < 0.05$). The results of the current investigation are in line with similar recent studies.[3,4,14,26]

It is worth noting that the DTS values of the other two composite resins were not affected when their fiber dowels (PFU and XPC) were introduced; this could indicate a stronger interfacial bond. The authors were not able to find any studies to support these findings.

Conclusion

Within the limitation of this study, the PFU group exhibited a significantly higher DTS value among the four fiber dowel systems ($P < 0.05$). The DTS values of two of the four composite resins decreased significantly when their matching fiber dowels were introduced ($P < 0.05$); SEM analysis showed cohesive failure at the resin core/dowel interfaces. There was no significant reduction in DTS values for the other two composite resins ($P > 0.05$); SEM analysis demonstrated mixed failure.

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References

1. Christensen GJ. Post concepts are changing. J Am Dent Assoc 2004;135(9):1674-1676.
2. Cheung W. A review of the management of endodontically treated teeth. Post, core, and final restoration. J Am Dent Assoc 2005;136(5): 611-619.
3. Fokkinga WA, Kreulen CM, Le Bell-Ronnlof AM, Lassila LV, Vallittu PK, Creugers NH. *In vitro* fracture behavior of maxillary premolars with metal crowns and several post-and-core systems. Eur J Oral Sci 2006;114(3):250-256.
4. Grandini S, Goracci C, Tay FR, Grandini R, Ferrari M. Clinical evaluation of the use of fiber posts and direct resin restorations for endodontically treated teeth. Int J Prosthodont 2005;18(5): 399-404.
5. Aksornmuang J, Foxton RM, Nakajima M, Tagami J. Microtensile bond strength of a dual-cure resin core material to glass and quartz fibre posts. J Dent 2004;32(6):443-450.
6. Campos TN, Arita CK, Missaka R, Katekawa L, Adachi EM. Influence of core materials in the microleakage of cast crowns. Cienc Odontol Bras 2005;8(4):13-17.
7. Artopoulou II, O'Keefe KL. Materials used in prefabricated post and core systems. A review of literature. Tex Dent J 2006;123(4):358-363.
8. Cho GC, Kaneko LM, Donovan TE, White SN. Diametral and compressive strength of dental core materials. J Prosthet Dent 1999;82(3):272-276.
9. Coelho Santos G Jr, El-Mowafy O, Rubo JH. Diametral tensile strength of a resin composite core with non-metallic prefabricated posts: An *in vitro* study. J Prosthet Dent 2004;91(4):335-341.
10 Simonetti M, Radovic I, Vano M, Chieffi N, Goracci C, Tognini F, Ferrari M. The influence of operator variability on adhesive cementation of fiber posts. J Adhes Dent 2006;8(6):421-425.
11. Seefeld F, Wenz HJ, Ludwig K, Kern M. Resistance of fracture and structural characteristics of different reinforced post systems. Dent Mater 2007;23(3):265-271. Epub 2006 Mar 6.

12. Heydecke G, Butz F, Strub JR. Fracture strength and survival rate of endodontically treated maxillary incisors with proximal cavities after restoration with different post and core systems: An *in-vitro* study. J Dent 2002;29(6):427-433.
13. Asmussen E, Peutzfeldt A, Sahafi A. Bonding of resin cements to post materials: Influence of surface energy characteristics. J Adhes Dent 2005;7(3):231-234.
14. Sahafi A, Peutzfeld A, Asmussen E, Gotfredsen K. Effect of surface treatment on prefabricated posts on bonding of resin cement. Oper Dent 2004;29(1):60-68.
15. Bitter K, Noetzel J, Neumann K, Kielbassa AM. Effect of silanization on bond strengths of fiber posts to various resin cements. Quintessence Int 2007;38(2):121-128.
16. Dietschi D, Ardu S, Rossier-Gerber A, Krejci I. Adapatation of adhesive post and cores to dentin after *in vitro* occlusal loading evaluation of post material influence. J Adhes Dent 2006;8(6): 409-419.
17. Gorucu J, Saygili G, Ozgunaltay G. Compressive shear bond strength of core buildup materials. Int J Periodontontics Restorative Dent 2006; 26(2):83-89.
18. Qing H, Zhu Z, Chao Y, Zhang W. *In vitro* evaluation of the fracture resistance of anterior endodontically treated teeth restored with glass fiber and zircon posts. J Prosthet Dent 2007; 97(2):93-98.
19. Purton DG, Chandler NP, Qualtrough AJ. Effect of thermocycling on the retention of glass fiber root canal posts. Quintessence Int 2003;34(5): 366-369.
20. Vano M, Goracci C, Monticelli F, Tognini F, Gabriele M, Tay FR, Ferrari M. The adhesion between fibre posts and composite resin cores: The evaluation of microtensile bond strength following various surface chemical treatments to posts. Int Endod J 2006;39(1):31-39.
21. Ferrari M, Goracci C, Sadek FT, Monticelli F, Tay FR. An investigation of the interfacial strengths of methacrylate resin-based fiber post-core buildups. J Adhes Dent 2006;8(4):239-245.
22. Goracci C, Raffaelli O, Monticelli F, Balleri B, Bertelli E, Ferrari M. The adhesion between prefabricated FRC posts and composite resin cores microtensile bond strength with and without post-silanization. Dent Mater 2005;21(5):437-444.
23. Monticelli F, Toledano M, Tay FR, Sadek FT, Goracci C, Ferrari M. A simple etching technique for improving the retention of fiber posts to resin composites. J Endod 2006;32(1):44-47.
24. Radovic I, Monticelli F, Goracci C, Cury AH, Coniglio I, Vulicevic ZR, Garcia-Godoy F, Ferrari M. The effect of sandblasting on adhesion of a dual-cured resin composite to methacrylic fiber posts microtensile bond strength and SEM evaluation. J Dent 2007;35(6):496-502. Epub 2007 Mar 19.
25. Craig RG. Restorative dental materials, ed. 1. New York: Elsevier;2001:83-84.
26. Salameh Z, Papacchini F, Ounsi HF, Goracci C, Tashkandi E, Ferrari M. Adhesion between prefabricated fiber-reinforced posts and different composite resin cores. A microtensile bond strength evaluation. J Adhes Dent 2006;8(2): 113-117.

Manufacturers

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Sodium hypochlorite, chlorhexidine gluconate, and commercial denture cleansers as disinfecting agents against *Candida albicans*: An *in vitro* comparison study

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When treating patients who have candidiasis, removable dental appliances in active use should be treated as well. The authors aimed to determine, *in vitro,* the lowest concentration of sodium hypochlorite that would eliminate *Candida albicans* biofilm, as well as the effectiveness of additional products against *C. albicans.* Strains of *C. albicans* formed biofilms on microtiter plates. Sodium hypochlorite was added in dilutions (1:1 to 1:512) and Peridex was added in concentrations of 25%, 50%, and 100%. The plates were incubated for 30 minutes. One tablet each of Efferdent, Polident for Partials, and Polident for Dentures was dissolved in 200 mL of sterile water and added to additional groups of plates. One group was incubated for 30 minutes; the other was incubated for 18 hours. An XTT spectrophotometric reduction assay measured biofilm metabolic activity.

Biofilm activity decreased 100% for all strains exposed to sodium hypochlorite for 30 minutes in concentrations of 1:32 or stronger. Biofilm activity decreased 100% for most strains when treated with 50% or 100% Peridex for 30 minutes and Polident for Dentures for 18 hours. From these results, it appears appropriate for providers to recommend a solution of two teaspoons of sodium hypochlorite in one cup of water (1:25) for 30 minutes to treat dentures contaminated with *C. albicans.*

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Oral candidiasis frequently results from *Candida* cell overgrowth, usually due to a decrease in the bacterial population; however, corticosteroid hormones, diabetes mellitus, anticancer agents, immunosuppressive drugs, viral infections, and poor oral hygiene in patients who wear dentures can frequently induce it.[1] There is growing evidence that *C. albicans* biofilms play an essential role in the development of denture stomatitis.[2] A recent study found that the incidence of *Candida* species in denture wearers was 66.7%.[3] The same study also found that the occurrence rate of oral candidiasis was higher in patients with dentures than in patients without dentures. Other studies have reported denture stomatitis in 11–67% of otherwise healthy denture wearers.[2]

C. albicans infections of the oral cavity are typified predominantly by biofilms. A *biofilm* is defined as a matrix-enclosed population of cells adherent to inert or biological surfaces, interfaces, and/or each other. It is characterized by the progression from the initial focal attachment of individual cells to a solid substratum to microcolonies and then to a complex, three-dimensional structure.[4] One of the consequences of biofilm growth is the markedly enhanced resistance to antimicrobial agents.[5] Therefore, there are inherent problems associated with the treatment of denture stomatitis and chronic atrophic candidiasis by conventional antifungal agents. To complement conventional antifungal therapy, strategies targeted at killing and removing *C. albicans* biofilms from dentures should be examined as appropriate adjunctive care.

Denture stomatitis is commonly treated with antifungal agents, administered either topically or systemically. Dentures can be used as carriers for topical antifungal agents, allowing longer contact time with the infected mucosa. Studies involving this treatment approach have been aimed at determining the beneficial effect on the patient's soft tissue and not on the denture itself. It is important to disinfect the dentures before and during treatment directed at the patient's soft tissue infection in order to prevent the dentures from acting as a continued source of reinfection.[6] Mechanical cleaning using denture brushes and paste is an effective method to clean dentures, but not to disinfect them. This method can remove plaque microorganisms; however, irregularities present in denture surfaces harbor bacteria and fungi not removed by regular brushing.

A variety of agents, in the form of soaking solutions, have been studied to determine their effectiveness in eliminating fungal organisms from dentures.[7,8] These include full-strength and dilute solutions of sodium hypochlorite (NaOCl), antiseptic mouthwashes such as Listerine and Peridex, glutaraldehyde, vinegar, sodium perborate, and commercial denture cleansers such as Polident and Efferdent.

It has been known for some time that chlorhexidine has a broad spectrum of antimicrobial activity, including *C. albicans* and other common non-albicans yeast species, and that pretreatment of denture acrylic with chlorhexidine gluconate significantly reduces the subsequent adherence of *C. albicans.*[8,9] Sodium hypochlorite, commonly known as *bleach,* is readily available in most homes, is inexpensive, has a broad spectrum of activity, and requires only a short period of time to be effective as a disinfectant.[7]

The use of sodium hypochlorite as an overnight soak has been shown to eliminate denture plaque.[10] Rodriguez *et al* suggested immersion in sodium hypochlorite for 30 minutes as the most effective method for the disinfection of acrylic resin prostheses.[11] However, soaking appliances in full-strength Clorox (5.25% NaOCl) has not been recommended due to the potential bleaching effect on the denture base, the corrosive effect of the chlorine ion on the metal components of removable partial dentures and some types of complete overdentures, and the unpleasant odor and taste imparted to the appliances.

A recent study reported the effectiveness of disinfectant solutions (1% sodium hypochlorite, 2% chlorhexidine digluconate, 2% glutaraldehyde, 100% vinegar, and a commercial denture cleanser) in the disinfection of cold-cured acrylic resin specimens contaminated *in vitro* by *C. albicans, Streptococcus mutans, S. aureus, Escherichia coli,* or *Bacillus subtilis.*[7] The results showed that 1% sodium hypochlorite, 2% glutaraldehyde, and 2% chlorhexidine digluconate were most effective. Vinegar demonstrated some degree of effectiveness against *C. albicans;* however, for this organism, there was no significant difference between the commercial denture cleanser (sodium perborate-based) and the control (no treatment).[7]

Investigators also have found microwave energy to be an effective method of removing fungal organisms from dentures.[10,12,13] However, this treatment method is not without significant limitations. First, there is not a recommended standard concerning time and power settings. Second, dentures can undergo dimensional changes; further, this method cannot be used on dentures with metal components, such as frameworks, pins on porcelain teeth, and metallic overdenture attachments.

The research goal of the present study was to develop a simple, inexpensive, and effective protocol using low-cost, readily available agents to eliminate fungal organisms from dental appliances with or without metal components that also can be easily accomplished by patients in their home. The specific aims of this *in vitro* study were to determine the lowest concentration of sodium hypochlorite that effectively eliminates *C. albicans* biofilms and to determine the effectiveness of 0.12% chlorhexidine gluconate (Peridex) as well as over-the-counter (OTC) denture cleansers (Polident for Partials, Polident for Dentures, and Efferdent) at eliminating *C. albicans* biofilms.

Materials and methods

C. albicans is a morphologically variable organism; as a result, total viable counts do not accurately reflect the number of viable cells, making quantification of disinfectant activity inaccurate. A 96-well microtiter plate method for *C. albicans* biofilm formation, coupled with a colorimetric XTT (2,3-bis(2-methoxy-4-nitro-5-sulfo-phenyl)-2H-tetrazolium-5-carboxanilide) metabolic assay (or microtiter assay) was used in this study.[11] This methodology allows simple, inexpensive, rapid, and accurate testing of the *in vitro* susceptibility of *C. albicans* biofilms to antifungal agents. This assay is reliant on the mitochondrial dehydrogenises of the live cells to convert an XTT tetrazolium salt into a reduced formazan-colored product that can be measured spectrophotometrically. This method minimizes handling, can be reproduced, and facilitated the goal of this study to test different disinfectant agents. It is nondestructive and does not require subsequent culture of cells. XTT absorbance readings are proportional to the cellular density of the biofilm. The microtiter plate reader determines the absorbance reading, which is compatible with the 96-well microtiter platform.[14]

C. albicans-type strains 3153A and SC5314 and *C. albicans* strains 6455 and 6309 isolated from patients with denture stomatitis were used in the present study. These isolates were stored on BBL Sabouraud dextrose slopes (BD) at 70°C. *C. albicans* was grown in yeast peptone dextrose (YPD) medium (1% w/v yeast extract,

Table 1. Clorox dilutions, 30-minute treatment.

Candida strain	1:1	1:2	1:4	1:8	1:16	1:32	1:64	1:128	1:256	1:512
6309	0	0	0	0	0	0	1	29	49	47
6455	0	0	0	0	0	0	0	0	1.6	29
3153A	0	0	0	0	0	0	0	1.5	25	38
SC5314	0	0	0	0	0	0	9	23	50	61

Note: Values are expressed as percent metabolic activity of cells within biofilms, determined by absorbance readings for XTT assays, as compared to control (untreated) wells that were considered 100%.

2% w/v peptone, 2% w/v dextrose [United States Biological]). Batches of this medium (20 mL) were inoculated from YPD agar plates containing freshly grown *C. albicans* and incubated overnight in an orbital shaker (100 rpm) at 30°C until the cells had reached a stationary phase of growth. Cells were harvested and washed in sterile phosphate buffered saline (PBS = 10 mM phosphate buffer, 2.7 mM potassium chloride, 137 mM sodium chloride, pH 7.4 [Sigma-Aldrich]). Cells were resuspended in RPMI-1640 supplemented with L-glutamine and buffered with morpholinepropanesulfonic acid (MOPS, Angus Chemical) to a cellular density equivalent to 5.0 x 106 cells/mL using a Bright Line hemocytometer (Hausser Scientific Company).

Biofilms were formed on commercially available, presterilized, polystyrene, flat-bottomed, 96-well microtiter plates (Corning Life Sciences). Biofilms were formed by pipetting 100 µL of standardized cell suspensions (1 x 10^6 cells/mL) into selected wells of the microtiter plate and incubating them for 48 hours at 37°C. Four isolates were grown on each plate so that Clorox (5.25% NaOCl; The Clorox Company) and Peridex (3M ESPE) had four replicates of each strain/plate; Polident for Dentures (GlaxoSmithKline), Polident for Partials (GlaxoSmithKline), and Efferdent (Prestige Brands, Inc.) had four replicates for each disinfectant/plate after 30 minutes of treatment; and Polident for Partials, Polident for Dentures, and Efferdent had four replicates for each disinfectant/plate after overnight treatment (18 continuous hours for the convenience of the primary investigator).

Following biofilm formation, the medium was aspirated, and nonadherent cells were removed by thoroughly washing the biofilms three times in sterile PBS. Residual PBS was removed by blotting with paper towels prior to the addition of disinfecting agents.

Sodium hypochlorite approximately 5.25% (Clorox) was added to the biofilms in serially double-diluted concentrations, up to 1/512 concentration of the original stock. The plate then was incubated for 30 minutes at room temperature. Peridex (0.12% chlorhexidine) was added to biofilms at three concentrations (25%, 50%, and 100%). The plate then was incubated for 30 minutes at room temperature. Efferdent, Polident for Dentures, and Polident for Partials tablets were dissolved in 200 mL of sterile water. The solutions were both added without any further dilution, and duplicate plates were incubated for either 30 minutes or overnight. Suitable positive and negative controls were included in all cases.

Biofilms were washed three times in sterile PBS to remove nonadherent cells and cells detached by the disinfectants. XTT (Sigma-Aldrich) then was added to each well of the 96-well plate to measure the metabolic activity of the biofilms following disinfectant challenge. The disinfectants were deemed effective if sterility was achieved (a 100% decrease in metabolic activity compared to the control).

A quantitative measure of biofilm formation was calculated using an XTT reduction assay, as described by Tellier *et al.*[15] Briefly, XTT was prepared in a saturated solution at 0.5 g/L in lactated Ringer's solution. This solution was filter-sterilized through a 0.22 µm-pore size filter (Corning Life Sciences), aliquoted, and stored at -70°C. Prior to each assay, an aliquot of stock XTT was thawed, and menadione (10 mM prepared in acetone [Sigma-Aldrich]) was added to a final concentration of 1.0 mM. One aliquot of XTT was added to each prewashed biofilm as well as to control wells to measure background XTT levels. The plates were incubated in the dark for one hour at 37°C. A colorimetric change of the XTT, a direct reflection of the metabolic activity of the biofilm, was measured in a microtiter plate reader at 490 nm. Before dispensing the test solution onto the plate, biofilms were washed three times with sterile PBS.

Biofilm formation in a 96-well microtiter plate was chosen to facilitate the serial dilution of NaOCl and to make it possible to use the XTT reduction assay method. A study by Webb *et al* has shown that adhesion of *Candida* species to polystyrene (the material with which the 96-well plates are made) was correlated with adhesion to acrylic ($I = 0.73$, $P = 0.017$).[10]

Results

The presence of *C. albicans* was evaluated spectophotometrically by the change of absorbance (Sigma-Aldrich) and by direct microscopy. All colorimetric readings were compared to the positive control group. An absorbance average was calculated and presented as a percentage (Tables 1–3).

A sodium hypochlorite dilution of up to 1:32 resulted in 100% decrease in absorbance; this represents a 100% decrease in metabolic activity (cell viability). Strains 6455 and 3153A also demonstrated a 100% decrease in absorbance when treated by a concentration of 1:64 sodium hypochlorite; however, this was not true for strains 6309 and SC5314 (Table 1).

A Peridex concentration of 25% was not effective against any of the strains of *C. albicans;* however, Peridex concentrations of both 50% and 100% resulted in a 100% decrease in absorbance of all strains of *C. albicans* except SC5314. Peridex was not able to remove the biofilm for that strain at full strength after a 30-minute application (Table 2).

Table 2. Peridex concentrations, 30-minute treatment.

Candida strain	25%	50%	100%
6309	1.1	0	0
6455	4.2	0	0
3153A	1.4	0	0
SC5314	3.9	1.1	3.45

Note: Values are expressed as percent metabolic activity of cells within biofilms, determined by absorbance readings for XTT assays, as compared to control (untreated) wells that were considered 100%.

Table 3. OTC/commercial denture cleansers: 30-minute and 18-hour treatments.

	Efferdent		Polident for Dentures		Polident for Partials	
Candida strain	30 min	18 h	30 min	18 h	30 min	18 h
6309	53	26	17	0	42	2
6455	55	0	4.5	0	66	0
3153A	40	0	0.9	0	34	0
SC5314	75	3	16.8	1.6	59	3.4

Note: Values are expressed as percent metabolic activity of cells within biofilms, determined by absorbance readings for XTT assays, as compared to control (untreated) wells that were considered 100%.

Thirty-minute applications of Efferdent, Polident for Dentures, and Polident for Partials were not completely effective against any of the *C. albicans* strains; however, overnight (18 continuous hours) applications resulted in partial effectiveness for each product, with Polident for Dentures indicating a 100% decrease in absorbance in all strains except SC5314. Efferdent and Polident for Partials were effective only on strains 6455 and 3153A (Table 3).

Discussion

Four strains of *C. albicans* were chosen to form the biofilms in the present study. Strain 6309, which makes a very adherent biofilm, and strain 6455, which makes a less-adherent biofilm, were used to compare results with the previous type strains, 3153A and SC5314.[14]

A semiquantitative, colorimetric technique was used as described earlier to detect the viability of cells within biofilms after treatment with disinfectants. Results as determined by the microtiter plate reader coincided with what was seen under the light microscope. This method of determining the vulnerability of biofilm to the antimicrobial solution is both quick and easy. It is computer-based, so the need to blind the researcher is not necessary and intraexaminer reliability cannot be a source of error.

Results obtained from the present study met the authors' expectations that sodium hypochlorite would be a potent disinfectant. A very weak solution (dilution of 1:128, or 1 cc Clorox in 127 cc water) eradicated strain 6455, which is logical, as it has the weakest adherence among all of the tested strains. A dilution of 1:64 (1 cc Clorox in 63 cc water) eradicated the typical clinical strain (3153A), while a dilution of 1:32 showed a 100% decrease in the metabolic activity of all strains, including strain SC5314, which typically forms densely packed, highly filamentous biofilms.

Absorbance readings of biofilms treated with 50% and 100% Peridex for 30 minutes showed a 100% decrease in metabolic activity of all strains except SC5314. This finding supports the recommendation by multiple authors that a chlorhexidine solution be used as a denture disinfectant to control colonization of the surface by *Candida* organisms.[6,16-18]

When testing the antifungal activity of the OTC denture cleansers Polident for Dentures, Polident for Partials, and Efferdent, one tablet of each product was dissolved in 200 mL of sterile water. The amount of water mimicked the amount that would be used by patients to ensure complete coverage of both the upper and lower dentures. A 30-minute treatment failed to produce 100% reduction in metabolic activity in any of the strains. Even after treatment for 18 hours, only Polident for Dentures demonstrated effectiveness against most strains of organisms (see Table 3). These results were in agreement with those of Moore *et al,* who found that denture cleansers were not effective under the clinical conditions of their study for the removal and/or killing of any of three microorganism groups cultured (aerobes, anaerobes, and yeasts).[19]

Nakamoto *et al* also found that denture cleansers with and without proteolytic enzymes showed little yeast lytic ability.[20] However, **Jose *et al,* from their evaluation of four commercial denture cleansers, found that** "denture cleansers exhibit effective anti-*C. albicans* biofilm activity, both in terms of removal and disinfection; however, residual biofilm retention that could lead to regrowth and denture colonization was observed. Therefore, alternative mechanical disruptive methods are required to enhance biofilm removal."[21]

A potential problem of using sodium hypochlorite as a soaking solution is its bleaching effect on acrylic. This effect is more likely to result from a long soaking time, such as overnight. Shortening the soaking time to 30 minutes reduces the likelihood of this problem occurring, as does the use of a diluted solution of sodium hypochlorite. One of the objectives of the present study was to determine the most dilute solution of sodium hypochlorite that would be effective against all of the tested strains of *C. albicans.* A 1:32 dilution of sodium hypochlorite met this objective.

The authors also wanted to provide simple instructions to patients that could be easily employed at home to disinfect removable appliances contaminated with *C. albicans.* Based on the outcomes of the present study, adding two teaspoons of Clorox to one cup of water (approximately a 1:25 dilution) and using it as a 30-minute soak should be as effective as a 1:32 dilution against *C. albicans.* The authors also can recommend using 50% strength Peridex (0.12% chlorhexidine) as a 30-minute soak for appliances containing metal. As a side note, Olsen reported that staining from the use of chlorhexidine could be removed with sodium hypochlorite.[22]

None of the OTC denture cleansers tested were effective disinfection agents when used as a 30-minute soak; however, both Polident for Dentures and Polident for Partials can be expected to be effective when used as an 18-hour soak.

Conclusion

The primary purpose of this study was to determine the lowest concentration of sodium hypochlorite that eliminates *C. albicans* biofilm, as well as the effectiveness of additional products against *C. albicans*. The authors also wanted to determine which of these solutions would be effective for a relatively short soaking time of 30 minutes.

Sodium hypochlorite in the form of Clorox diluted with water up to a concentration of 1:32 used as a 30-minute soak was the most dilute antifungal agent that maintained complete efficacy; this was followed by a 50% solution of Peridex. Polident for Dentures and Polident for Partials also can be expected to be effective when used as an 18-hour soak. However, the authors concur with Jose *et al* in recommending that mechanical disruptive methods be used in conjunction with a soaking solution to enhance biofilm removal.[21]

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References

1. Osaki T, Yoneda K, Yamamoto T, Ueta E, Kimura T. Candidiasis may induce glossodynia without objective manifestation. Am J Med Sci 2000; 319(2):100-105.
2. Coenye T, De Prijck K, De Wever B, Nelis HJ. Use of the modified Robbins device to study the in vitro biofilm removal efficacy of NitrAdine, a novel disinfecting formula for the maintenance of oral medical devices. J Appl Microbiol 2008; 105(3):733-740.
3. Daniluk T, Tokajuk G, Stokowska W, Fiedoruk K, Sciepuk M, Zaremba ML, Rozkiewicz D, Cylwik-Rokicka D, Kedra BA, Anielska I, Gorska M, Kedra BR. Occurrence rate of oral *Candida albicans* in denture wearer patients. Adv Med Sci 2006;51 (Suppl 1):77-180.
4. Ramage G, Tomsett K, Wickes BL, Lopez-Ribot JL, Redding SW. Denture stomatitis: A role for *Candida* biofilms. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;98(1):53-59.
5. Ramage G, Martinez JP, Lopez-Ribot JL. *Candida* biofilms on implanted biomaterials: A clinically significant problem. FEMS Yeast Res 2006;6(7): 979-986.
6. Olsen I. Denture stomatitis. Effects of chlorhexidine and amphotericin B on the mycotic flora. Acta Odontol Scand 1975;33(2):41-46.
7. da Silva FC, Kimpara ET, Mancini MN, Balducci I, Jorge AO, Koga-Ito CY. Effectiveness of six different disinfectants on removing five microbial species and effects on the topographic characteristics of acrylic resin. J Prosthdont 2008; 17(8):627-633.
8. McCourtie J, MacFarlane TW, Samaranayake LP. Effect of chlorhexidine gluconate on the adherence of *Candida* species to acrylic surfaces. J Med Microbiol 1985;20(1):97-104.
9. Ellepola ANB, Samaranayake LP. Adjunctive use of chlorhexidine in oral candidoses: A review. Oral Dis 2001;7(1):11-17.
10. Webb BC, Thomas CJ, Wilcox MD, Harty DW, Knox KW. *Candida*-associated denture stomatitis. Aetiology and management: A review. Part 3. Treatment of oral candidosis. Aust Dent J 1998;43(4):245-249.
11. Rodriguez EA, Reis RF, Camargo RW. Eficacia de tres desinfetantes em proteses totais a base de resina acrilica. [Article in Portuguese.] Odontol Mod 1994;21:11-15.
12. Silva MM, Vergani CE, Giampaolo ET, Neppelenbroek KH, Spolidorio DM, Machado AL. Effectiveness of microwave irradiation on the disinfection of complete dentures. Int J Prosthodont 2006;19 (3):288-293.
13. Sanita PV, Vergani CE, Giampaolo ET, Pavarina AC, Machado AL. Growth of *Candida* species on complete dentures: effect of microwave disinfection. Mycoses 2009;52(2):154-160.
14. Ramage G, Vande Walle K, Wickes BL, Lopez-Ribot JL. Standardized method for in vitro antifungal susceptibility testing of *Candida albicans* biofilms. Antimicrob Agents Chemother 2001; 45(9):2475-2479.
15. Tellier R, Krajden M, Grigoriew GA, Campbell I. Innovative endpoint determination system for antifungal susceptibility testing of yeasts. Antimicrob Agents Chemother 1992;36(8):1619-1625.
16. Budtz-Jorgensen E. Etiology, pathogenesis, therapy, and prophylaxis of oral yeast infections. Acta Odontol Scand 1990;48(1):61-69.
17. Zegarelli DJ. Fungal infections of the oral cavity. Otolaryngol Clin North Am 1993;26(6):1069-1089.
18. Banting DW, Hill SA. Microwave disinfection of dentures for the treatment of oral candidiasis. Spec Care Dent 2001;21(1):4-8.
19. Moore TC, Smith DE, Kenny GE. Sanitization of dentures by several denture hygiene methods. J Prosthet Dent 1984;52(2):158-163.
20. Nakamoto K, Tamamoto M, Hamada T. Evaluation of denture cleansers with and without enzymes against *Candida albicans*. J Prosthet Dent 1991;66(6):792-795.
21. Jose A, Coco BJ, Milligan S, Young B, Lappin DF, Bragg J, Murray C, Ramage G. Reducing the incidence of denture stomatitis: Are denture cleansers sufficient? J Prosthodont 2010;19(1): 252-257.
22. Olsen I. Denture stomatitis. Relapse tendency and removal of acquired discolourations in long-term denture disinfection with chlorhexidine. Acta Odontol Scand 1975;33(2):111-114.

Manufacturers

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800.447.4369, www.dow.com/angus

BD, Franklin Lakes, NJ
201.847.6800, www.bd.com

Corning Life Sciences, Lowell, MA
800.492.1110, www.corning.com/lifesciences

The Clorox Company, Oakland, CA
510.271.7000, www.clorox.com

GlaxoSmithKline, Research Triangle Park, NC
866.844.2796, www.mypolicare.com

Hausser Scientific Company, Horsham, PA
215.675.7769, www.hausserscientific.com

Prestige Brands, Inc., Irvington, NY
877.925.5374, www.efferdent.com

Sigma-Aldrich, St. Louis, MO
800.325.3010, www.sigmaaldrich.com

United States Biological, Swampscott, MA
800.520.3011, www.usbio.net

3M ESPE, St. Paul, MN
800.634.2249, solutions.3m.com

Diagnosis and treatment of dry mouth

Medha Singh, BDS, DMD, MS ▪ Rajinder Singh Tonk, MD

For effective management of dry mouth, early diagnosis and aggressive, symptom-based treatment are necessary to help alleviate much of the discomfort and to retard progression of the disorder. Many effective strategies are available to help patients manage their symptoms. Routine follow-up care with physicians and dentists is essential. With early intervention and proper individualized care, people with dry mouth should be able to lead full and comfortable lives.

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Dry mouth is seen most commonly in patients receiving radiation therapy for the treatment of cancer of the head and neck or in those who undergo surgical removal of the salivary glands due to salivary gland tumor or stones (sialolith). It also is seen as a frequent side effect of prescription and nonprescription drugs, including drugs used to treat depression, anxiety, pain, allergies and colds (antihistamines and decongestants), epilepsy, hypertension (diuretics), diarrhea, nausea, psychotic disorders, urinary incontinence, asthma (certain bronchodilators), and Parkinson disease, as well as muscle relaxants and sedatives.[1]

Dry mouth is seen in certain autoimmune disorders such as Sjogren syndrome, rheumatoid arthritis, systemic lupus erythematosus, and scleroderma, as well as other medical conditions including HIV/AIDS, Alzheimer disease, diabetes, anemia, cystic fibrosis, hypertension, Parkinson disease, stroke, and mumps. Other factors that can affect saliva production and aggravate dry mouth include dehydration due to fever, excessive sweating, vomiting, diarrhea, smoking or chewing tobacco, and mouth breathing.[1]

Symptoms

The common symptoms of dry mouth include a sticky, dry feeling in the mouth and throat, frequent thirst, cracked corners of the mouth, and cracked lips. Dry mouth causes difficulty in swallowing, speaking, chewing, and wearing dentures; changes in taste; a burning or tingling sensation in the mouth, especially on the tongue; sores on the oral mucosa; fissured tongue or dry, red, raw tongue; and increased susceptibility to oral candidiasis. Dry mouth also results in rampant decalcification of enamel, cervical dental caries, and acid erosion, as well as increased accumulation of bacterial plaque, associated gingival inflammation, periodontal disease, and halitosis.[1]

Diagnosis

Patients should be questioned in greater detail about their dryness. Questions that focus on oral activities dependent on salivation, such as chewing and swallowing, help to identify patients with salivary hypofunction and further evaluation should be conducted to confirm diagnosis (Table 1).

Patients with dry mouth who respond positively to these questions are diagnosed as having salivary hypofunction and have a lower median flow rate than those who respond negatively.[2]

Unstimulated and stimulated salivary function tests are used to determine the actual severity of xerostomia.[3] Unstimulated salivary samples require that the patient have had nothing by mouth for at least 60 minutes. Oral activities such as toothbrushing or flossing are restricted for this time period. Unstimulated "whole" saliva includes the output of the major and minor salivary glands. When the test is performed, patients are instructed to sit upright and allow saliva to accumulate passively in the mouth without swallowing. Patients are instructed to spit the contents of the mouth into a receptacle at one-minute intervals. A collection of at

Table 1. Questions that can help to identify patients with salivary hypofunction.

- Do you sip liquids to aid in swallowing dry foods?
- Does your mouth feel dry when eating a meal?
- Do you have difficulties swallowing any foods?
- Does the amount of saliva in your mouth seem to be too little?
- Does your nose or throat feel dry and tickly?
- Do you have a dry cough, hoarseness, nosebleeds, and/or a decreased sense of taste or smell?

least five minutes is recommended. The volume collected can be determined directly when collected in a graduated cylinder or by weight (1 gram = 1 mL). An output of less than 0.1 mL per minute is widely accepted as being abnormally low.[3]

Stimulated saliva is collected following stimulation of the salivary glands, which is usually done by chewing plain or flavored gum or paraffin wax. Because the rate and vigor of chewing and the amount and type of flavoring can affect the flow rate, these factors must be standardized for reproducibility. Chewing an unflavored gum base or paraffin at a rate of 60 chews per minute is a common approach; a collection of at least two minutes is recommended. Salivary output below 0.7 mL per minute is indicative of marked salivary hypofunction.[3]

Lip biopsy involves performing a biopsy of minor salivary glands in the lower lip. The labial minor salivary gland biopsy is considered the optimal sole diagnostic criterion for the salivary component of Sjogren syndrome. For Sjogren syndrome, the biopsy report should include a focal score of 1 or more.[4]

Serologic and laboratory tests are performed to detect autoimmune disorders that indicate salivary hypofunction. A positive blood result for SSA (anti-Ro) and SSB (anti-La) antibodies is diagnostic for Sjogren syndrome; a positive blood result for antinuclear antigen (ANA) is diagnostic for systemic lupus; and a positive result for rheumatoid factor (RF) is diagnostic for rheumatoid arthritis.[5] Such autoimmune disorders have symptoms of joint pain in addition to dry eyes, so patients should be referred to a rheumatologist and an ophthalmologist. Panoramic radiographs or CT scans are conducted to check for salivary gland stones or salivary gland tumors.[2]

Management

For effective management of dry mouth, early diagnosis and aggressive, symptom-based treatment can help to alleviate much of the discomfort, retard the progression of the disorder, and promote comfort and productivity.[6]

Xerostomia increases the vulnerability of tooth enamel. Patients with dry mouth are at high risk for dental caries, so an extra effort must be made to protect teeth from decalcification and dental caries. A comprehensive dental examination including bitewing radiographs should be performed annually to detect any new carious lesions. Patients with xerostomia require aggressive fluoride therapy in the form of professionally applied concentrated sodium fluoride varnishes and the daily use of a prescription-strength fluoride toothpaste. Calcium also has a remineralizing effect on dental enamel, so a calcium-containing remineralizing oral rinse is recommended as well.[2]

Patients with dry mouth are also at high risk for periodontal disease. Dentists and dental hygienists should reinforce the importance of regular brushing and flossing. An electric toothbrush is recommended to most effectively remove plaque and prevent gingivitis.[7] Patients should receive periodontal prophylaxis every three months, followed by an in-office application of fluoride varnish.[8] Antibacterial rinses such as 0.12% chlorhexidine are indicated to reduce gingivitis.[2] Patients should be referred to a periodontist if they have early signs of periodontitis.

Oral candidiasis is frequently an issue for patients with Sjogren syndrome. Patients should be prescribed topical antifungal rinses or lozenges (with clotrimazole) for treatment of oral candidiasis. A systemic antifungal medication, such as fluconazole, is recommended for recurrent oral candidiasis or when topical antifungal agents are ineffective.[2]

Nonselective muscarinic receptor agonists, such as pilocarpine or civemiline, can be prescribed for patients to promote salivary function. These are parasympathomimetic drugs and act therapeutically at the muscarinic acetylcholine receptor M3 subtype and stimulate saliva production. Sialagogues should always be taken with food.[9] Patients who are unable to afford prescription medications or unable to tolerate them due to their side effects can use OTC products.

The use of xylitol gum containing salivary stimulants can help to stimulate salivary flow for patients who have remaining functional salivary glands. Xylitol is an FDA-approved therapeutic sweetener that helps to arrest dental caries due to its interference with the growth of cariogenic bacteria.[2]

Xerostomia can cause the oral mucosa to become dry and sore. Oral lubricants such as vitamin E are effective in soothing irritated oral tissues. Patients are advised to break the vitamin E capsule and apply it topically to irritated oral tissues. Xerostomia also can cause the lips to become dry; to soothe them, regular use of topically applied oil-based balms or a vitamin E-containing balm is suggested.

Dry mouth sufferers should try to minimize any factors that could exacerbate their symptoms. Xerostomia has been reported as a side effect in approximately 80% of the most commonly prescribed medications, such as antihistamines and decongestants; this can compound the discomfort of patients who already have xerostomia from other causes. If possible, alternative, non-xerostomic medications should be used as substitutes.[10] The prevalence of medication-induced xerostomia is particularly high in the elderly population.[10] More than 85% of people age 60 years and older are taking at least one prescription medication.

Patients with xerostomia should be counseled to avoid products that can contribute to oral dryness or irritation, including alcohol, caffeine, and tooth-whitening products. Alcohol has a drying effect and should be avoided in beverages and in oral products such as mouthwashes. Caffeine is a mild diuretic that promotes fluid loss and can worsen the symptoms of dry mouth. If possible, patients should avoid or limit items that contain significant amounts of caffeine, such as coffee, tea, and soft drinks. Tooth-whitening products also should be avoided, as they can irritate friable oral tissues.

Patients who tend to breathe through their mouths should be encouraged to try to increase nasal breathing and to be examined by an otolaryngology specialist to determine if there are impediments to normal nasal breathing. The dry ambient air of most modern homes also can contribute to sensation of dryness. The use of a humidifier, particularly at night, helps to address this concern.[2]

Patients are advised to minimize consumption of foods and beverages high in carbohydrates between meals, especially sticky foods such as cookies, bread, potato chips, gums, candies, and acidic beverages (such as most carbonated and sports drinks) and citrus products, especially lemony ones. Frequent sips of small amounts of sugar-free fluids, especially water, can be helpful in diminishing the effects of oral dryness. Many patients keep a bottle of water handy to moisturize their oral tissues; however, excessive water sipping can actually reduce the oral mucosal film lining the mouth and worsen dry mouth symptoms.[2]

Summary

Early diagnosis and treatment of xerostomia are extremely important to prevent damage to the oral cavity. Many effective strategies are available to help patients with dry mouth manage their symptoms. Routine follow-up care with the physician and the dentist is essential. With early intervention and thorough, individualized care, people with xerostomia should be able to lead full and comfortable lives.

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References

1. Guggenheimer J, Moore PA. Xerostomia: Etiology, recognition and treatment. J Am Dent Assoc 2003;134(1):61-69.
2. Brennan M, Fox P. Xerostomia: Diagnosis, management, and Sjogren's syndrome. *In:* Brennan M, Fox P, ed. Clinician's guide: Salivary gland and chemosensory disorders, ed. 1. Hamilton, Ont: BC Decker Inc.;2008:5-25.
3. Sreebny L. Saliva—Salivary gland hypofunction (SGH). FDI Working Group 10. J Dent Assoc S Afr 1992;47(11):498-501.
4. Hocevar A, Ambrozic A, Rozman B, Kveder T, Tomsic M. Ultrasonographic changes of major salivary glands in primary Sjogren's syndrome. Diagnostic value of a novel scoring system. Rheumatol 2005;44(6):768-772. Epub 2005 Mar 1.
5. Longman LP, Higham SM, Bucknall R, Kaye SB, Edgar WM, Field EA. Signs and symptoms in patients with salivary gland hypofunction. Postgrad Med J 1997;73(856):93-97.
6. Scagliusi P, Minenna G, D'Amore M, Scagliusi A. New therapeutic perspectives in Sjogren's syndrome: Leflunomide. Recenti Prog Med 2005; 96(4):194.
7. Martuscelli G, Singh M, Papas AS, Cohen J. Use of a power toothbrush in a high risk population. J Dent Res 2004;83(special issue A):2435.
8. Derk CT, Vivino FB. A primary care approach to Sjogren's syndrome. Helping patients cope with sicca symptoms, extraglandular manifestations. Postgrad Med 2004;116(3):49-54.
9. Papas A, Sherrer YS, Charney M, Golden HE, Medsger TA Jr, Walsh BT, Trivedi M, Goldlust B, Gallagher SC. Successful treatment of dry mouth and dry eye symptoms in Sjogren's syndrome patients with oral pilocarpine. A randomized, placebo-controlled, dose-adjustment study. J Clin Rheumatol 2004;10(4):169-177.
10. Bowman J, Shirodaria S, Gallagher A, Hamlin D. Demographic profile of subjects with medication-induced xerostomia at three locations. J Dent Res 2007;86(special issue A):1106.

The influence of different placement techniques on the microtensile bond strength of low-shrink silorane composite bonded to Class I cavities

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The aim of this *in vitro* study was to evaluate the microtensile bond strength (μTBS) of a low-shrink silorane-based composite (Filtek Silorane) and a methacrylate-based composite (Filtek Z250) to the bottom dentin of a Class I cavity using different placement techniques. Twelve third molars were used. Standard, box-type Class I cavities (6.0 x 4.0 x 2.5 mm) were prepared at the occlusal crown center, with the pulpal floor ending approximately at the midcoronal dentin. The teeth were then randomly divided into four groups, according to each placement technique: ZI—Filtek Z250 placed incrementally; ZB—Filtek Z250 placed in bulk; SI—Filtek Silorane placed incrementally; and SB—Filtek Silorane placed in bulk. Each restored third molar was subjected to microtensile bond testing after 24 hours of storage in distilled water at 37°C. After storage, each molar was longitudinally sectioned in both axes to obtain rectangular sticks with an approximate 0.49 mm^2 cross-sectional area. Data were analyzed by one-way ANOVA followed by a Tukey *post hoc* test ($P \leq 0.05$). After debonding, the failure modes were analyzed using a stereomicroscope.

The ZI group (72.6 MPa) showed the highest μTBS, followed by the ZB group (60.2 MPa), while the SI (34.4 MPa) and SB (42.6 MPa) groups demonstrated statistically significant lower bond strengths. The type of placement technique did not influence the μTBS of silorane-based composites to the bottom dentin of Class I cavities. The methacrylate-based composite showed superior performance, regardless of the placement technique.

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The use of methacrylate-based composite resin restorative materials has been widely accepted in dental practice.[1,2] However, improvements aiming to reduce the inherent polymerization shrinkage of the current materials are still necessary.[3,4] Problems associated with polymerization shrinkage are common: imperfect marginal sealing (which can result in secondary caries), marginal staining, and postoperatory sensitivity.[5] Polymerization shrinkage also can lead to cuspal displacement and even to cracks in healthy tooth structure.[6]

To minimize stress from polymerization shrinkage, efforts have been directed toward improving placement techniques, curing methods, and composite formulation.[4] For methacrylate-based composites, the incremental layering technique, based on polymerizing composite layers less than 2.0 mm thick, has been considered the best way to minimize the effects of the polymerization shrinkage.[7,8] As for the composite formulation, many attempts have been made over the past few years to change the composite nature.[9-11]

A novel oxirane-based composite, called *silorane*, has been synthesized from the reaction of oxiranes and siloxane molecules. It is based on using ring-opening polymerization of the silorane molecules instead of free radical polymerization of methacrylate monomers. The ring-opening polymerization of a silorane molecule is a cationic polymerization reaction in which no oxygen inhibition layer exists on the composite surface. It has been postulated that this new composite provides increased hydrophobicity, improved biocompatibility compared to methacrylate-based composites, and decreased polymerization shrinkage (less than 1%, whereas most of methacrylate-based composites present 2–5% volumetric shrinkage).[12-16] The incremental placement technique minimizes the stress from polymerization shrinkage of methacrylate-based composites.[4,7,8] On the other hand, manufacturers claim that there is no need for the incremental placement technique when the low-shrink Filtek Silorane composite (3M ESPE) is used; therefore, bulk placement is recommended.[2]

Table 1. Materials used in this study.

Materials	Material composition
Scotchbond Multi-Purpose	*Etchant:* 35% H_3PO_4; *Primer:* copolymer of polyalkenoic acid, HEMA, water; *Resin:* HEMA, bis-GMA
Silorane System Adhesive Bond	TEGDMA, phosphoric acid methacryloxyhexylesters, 1,6-hexanediol dimethacrylate bis-GMA, UDMA, bis-EMA
Filtek Z250	Bis-GMA, UDMA, bis-EMA
Filtek Silorane	1,3,5,7-Tetrakis(ethyl cyclohexane epoxy)-1,3,5,7-tetramethyl cyclotetrasiloxanemethyl-bis[2-(7-oxabicyclo[4.1.0]hept-3-yl)ethyl]phenyl

Bis-GMA = bisphenol A-glycidyl dimethacrylate; TEGDMA = triethylene glycol dimethacrylate; UDMA = urethane dimethacrylate; bis-EMA = bisphenol A polyethylene glycol diether dimethacrylate; HEMA = 2-hydroxyethilmethacrylate.

Table 2. Adhesives used in this study and their respective application techniques.

Adhesive	Application technique
Scotchbond Multi-Purpose	35% H_3PO_4 acid etch (30 seconds for enamel and 15 seconds for dentin), rinse (30 seconds), air dry, primer (30 seconds), air dry, adhesive, photocure (20 seconds).
Silorane System Adhesive Bond	Primer (15 seconds), air dry, photocure (10 seconds), adhesive, air dry, photocure (10 seconds).

The aim of this current study was to evaluate the influence of different placement techniques on the microtensile bond strength (μTBS) of low-shrink Filtek Silorane composite bonded to the bottom dentin of Class I cavities.

Materials and methods

The materials used in the present study are listed in Table 1. Twelve human third molars were stored in distilled water at 4°C, with the storage medium renewed weekly, and used within three months of extraction.

Standard, box-type, Class I cavities (6.0 x 4.0 x 2.5 mm) were prepared at the occlusal crown center with the pulpal floor ending approximately at the midcoronal dentin, using a high-speed handpiece with cylindrical high, medium, and fine grit diamond burs (KG Sorensen), respectively. The diamond bur was positioned perpendicularly to the long axis of the tooth to create a 2.5 mm deep cavity. Such cavity depth standardization was achieved by leveling the upper portion of the diamond bur (4.0 mm long) with the tooth marginal ridges. The prepared teeth were then randomly assigned to one of four experimental groups (three molars per group): SB—Filtek Silorane placed in bulk; SI—Filtek Silorane placed incrementally; ZI—Filtek Z250 placed incrementally; and ZB—Filtek Z250 placed in bulk. All Filtek Silorane layers were less than 2.5 mm thick, and all materials were used according to the manufacturer's instructions and subjected to bonding treatments outlined in Table 2.

Placement technique

After the bonding treatment, the placement technique applied for each experimental group was performed as described below.

SB—Filtek Silorane shade A3 composite was placed in bulk with <2.5 mm thick increments and photocured for 40 seconds using a halogen photocuring device (Elipar 2500 curing light, 3M ESPE) at 400mW/cm^2.

SI—Filtek Silorane shade A3 composite was placed in five increments (<2.0 mm thick) without linking the opposing cavity internal walls. Each increment was photocured for 40 seconds using a halogen photocuring device (Elipar 2500 curing light) at 400mW/cm^2.

ZI—Filtek Z250 shade A3 composite was placed in five increments (<2.0 mm thick) without linking the opposing cavity internal walls. Each increment was photocured for 40 seconds using a halogen photocuring device (Elipar 2500 curing light) at 400mW/cm^2.

ZB—Filtek Z250 shade A3 composite was placed in bulk with <2.5 mm thick increment and photocured for 40 seconds using a halogen photocuring device (Elipar 2500 curing light) at 400mW/cm^2.

Microtensile bond strength testing

Each restored molar was subjected to microtensile bond testing after storage in distilled water at 37°C for 24 hours. After storage, each molar was longitudinally sectioned along both axes to obtain rectangular sticks with a cross-sectional area of approximately 0.49 mm^2. The sticks then were fixed to a Geraldelli jig using cyanocrilate glue applied to both extremities of each stick.[17] The sticks were stressed in a universal testing machine (Instron 4444, Instron Corp.) at a crosshead speed of 0.5 mm/min until failure. The µTBS was expressed by the following equation: MPa = N/mm^2.

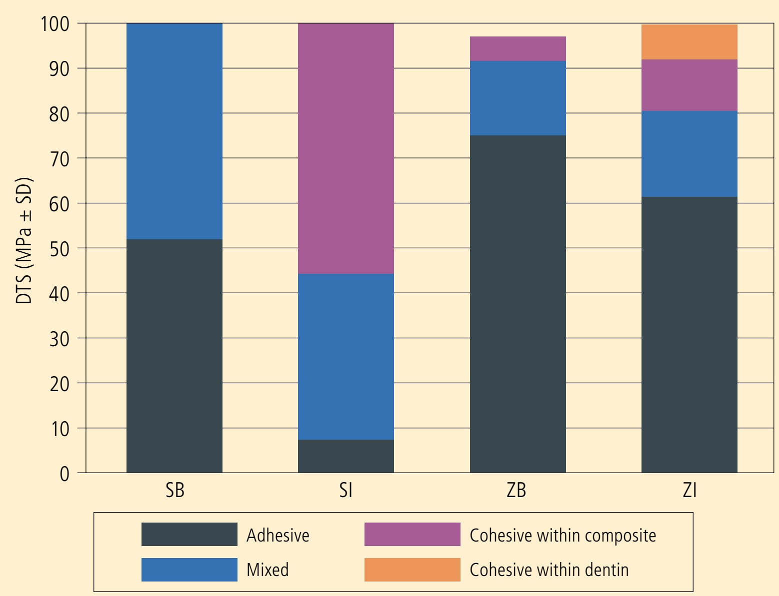
The failure mode of each stick was analyzed under 40x magnification microscopy (Olympus America) after debonding. The failure mode was determined using an adaptation of the Hashimoto classification system.[18] The failures were classified as adhesive (type A), resin cohesive (type B), dentin cohesive (type C), or mixed (adhesive failure with some dentin or resin cohesive involvement) (type D). The statistical analyses were conducted using ANOVA ($P \leq 0.05$) and a *post-hoc* Tukey test.

Table 3. µTBS for each group to Class I cavity bottom dentin.

Group	Placement technique	MPa (SD)
SB	Bulk	42.9 (17.6)[a]
SI	Incremental	34.4 (17.6)[a]
ZB	Bulk	60.2 (24.3)[b]
ZI	Incremental	72.6 (27.0)[b]

Note: Different superscript letters indicate significantly different results.

Chart 1. Prevalence (percentage) of failure patterns for all experimental groups.



Results

Microtensile bond strength

The overall bond strength values (MPa) and standard deviations (SDs) for the experimental groups are presented in Table 3. The ZI group demonstrated the highest µTBS mean value, followed by the ZB group, while the SI and SB groups indicated statistically lower µTBS mean values. The SI group exhibited the lowest µTBS mean value among all groups. One-way ANOVA and a *post-hoc* Tukey test revealed no significant correlation between placement technique and µTBS; however, significant differences were exhibited regarding the type of restorative material used ($P \leq 0.05$).

Failure mode analysis

Chart 1 shows the proportional prevalence (percentage) of the failure patterns for all experimental groups. For the SB group, adhesive and mixed failures occurred in similar proportions. However, cohesive failure within composite was the predominant pattern for the SI group. Adhesive failure was the common and predominant pattern for both the ZB and ZI groups, with a greater prevalence in the former.

Discussion

The polymerization of a composite material is accompanied by a volume reduction that produces contraction stress where the composite contacts the tooth. These stresses, in turn, can affect the tooth-composite interface.[19] Presumably, a silorane composite stands as an alternative to overcome the polymerization shrinkage stress inherent in methacrylate-based composites, and they are indicated for posterior restorations due to their less than 1% polymerization shrinkage. Therefore, the manufacturer's instructions recommend that silorane composites be placed in bulk, because there is no need for a special placement technique to minimize the polymerization shrinkage stress.

Preliminary studies of Class I, box-type cavities have shown that there is a correlation between polymerization shrinkage and bond strength.[19,20] This *in vitro* study was designed to test the influence of placement technique on a silorane-based composite in a clinical "worst case scenario"—Class I cavities—to provide a high C-factor.[19,20] Consequently, the clinically relevant effect of polymerization stress could be assessed.

Bond strength values decrease as the cavity's C-factor increases.[19,20] This finding is commonly attributed to the polymerization shrinkage of composite resins; these resins transfer stress to the tooth/restoration interface during setting. However, since silorane is a low-shrink composite, it is unlikely that shrinkage stress is the cause of low bond strength values.

However, even though the low-shrinkage properties of silorane are desirable, they do not solve all of the adhesion problems.[20] In the current study, the μTBS values of a silorane-based composite bonded to Class I, cavity-bottom dentin were significantly lower than the values achieved with a methacrylate-based composite, regardless of the placement technique applied, showing that the inherent low-shrinkage property of silorane is not the ultimate factor that reduces bond strength and that the silorane system adhesive was not as effective as the traditional, methacrylate-based, three-step, etch-and-rinse adhesive.

To provide an appropriate bond between silorane composite and tooth hard tissues, a dedicated adhesive was developed by the manufacturer. The silorane system adhesive is composed of a self-etch primer and an adhesive bonding agent. The silorane primer contains hydrophilic and etching monomers that bond to hydrated dentin, while the silorane bonding agent contains hydrophobic bifunctional monomers that match the hydrophobic silorane resin. Both must be cured separately and should be considered as one-step systems and compared with one-step systems.[21]

According to Duarte *et al,* the application of silorane primer on dentin produces intense intertubular decalcification, resulting in an exposed collagen network, while dentinal tubules remain blocked out by smear plugs.[22,23] After the application and polymerization of the silorane bond coating resin, a 1.9 μm hybrid layer with few resin tags is observed.[21,23] In fact, it has been demonstrated that the hybrid layer thickness created with the silorane adhesive is thinner than that of etch-and-rinse adhesives and equivalent to that of one-step, self-etch adhesives.[21] The results of the present study demonstrate that a silorane-based composite could not achieve μTBS values as high as those for a three-step, etch-and-rinse adhesive associated with a methacrylate-based composite. This finding is logical, considering that one-step, self-etch adhesives generally perform very poorly with respect to immediate bond strength and short-term bonding effectiveness.[24,25]

Santini and Miletic conducted a study using 2D, confocal, micro-Raman spectroscopy.[21] According to their results, both the silorane primer and bond showed distinctive spectra, indicating separately cured layers of primer and bond. Although the bond was placed on the cured primer surface prior to being cured itself, Raman spectra indicated an intervening zone of approximately 1 μm of mixed spectral intensities associated with both the primer and bond; this can be attributed to an oxygen inhibition layer remaining at the cured primer surface. This intervening zone could have acted as a weak link in the silorane bonding system, thus causing lower μTBS values. With these results in mind, further research on more accurate fractography methods is necessary to assess whether failure occurs within the silorane adhesive system.

Although there was no statistical difference in the present study, the incremental technique associated with the traditional, three-step, etch-and-rinse adhesive and methacrylate-based composite achieved the highest μTBS value, demonstrating the effectiveness of this procedure on minimizing the effects of polymerization shrinkage.

As for the silorane-based composite, the SB group achieved higher bond strength values than the SI group. This indicates that the silorane-based composite should be placed in bulk, as recommended by the manufacturer, because bonding between successive layers depends on the reactivity of the material, since silorane composite systems are hydrophobic and no oxygen inhibition layer is present. Indeed, in the present study, the SI group failure mode analysis showed a high predominance of cohesive failures within the composite and the lowest μTBS values among all tested groups.

Another important finding in the present study is that chemical reactivity between successive layers decays over time, as does the bond strength between them.[2] As a result, the placement technique of the SI group did not take more than 20 seconds from placement until curing of the subsequent increment.

Although the bond strength of the silorane bonding agent was significantly lower than that of the methacrylate agent, this does not necessarily mean that the silorane system will not succeed clinically, because it might not require a very strong adhesive interface, since the silorane-based interface is not exposed to the same degree of polymerization shrinkage stress as a methacrylate-based interface. Furthermore, evaluations regarding aspects such as marginal sealing, cuspal displacement, and *in vivo* longevity also are important in determining whether a composite is clinically effective.

Conclusion

The type of placement technique did not influence the μTBS of a silorane-based composite to Class I, cavity-bottom dentin. The methacrylate-based composite demonstrated superior performance, regardless of placement technique.

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References

1. Leinfelder KF. New developments in resin restorative systems. J Am Dent Assoc 1997;128(5):573-581.
2. Tezvergil-Mutluay A, Lassila LV, Vallittu PK. Incremental layers bonding of silorane composite: The initial bonding properties. J Dent 2008;36(7):560-563.
3. Pearson JD, Bouschlicher MR, Boyer DB. Polymerization shrinkage forces of condensable composites. J Dent Res 1999;789(special issue):448.
4. Deliperi S, Bardwell DN. An alternative method to reduce polymerization shrinkage in direct posterior composite restorations. J Am Dent Assoc 2002;133(10):1387-1398.
5. Palin WM, Fleming, Nathwani H, Trevor B, Randall Ros C. *In vitro* cuspal deflection and microleakage of maxillary premolars restored with novel low-shrink dental composites. Dent Mater 2005;21(4):324-335.
6. Weinnmann W, Thalacker C, Guggenberger R. Siloranes in dental composites. Dent Mater 2005;21(1):68-74.
7. Davidson CL. Resisting the curing contraction with adhesive composites. J Prosthet Dent 1986;55(4):446-447.
8. Lutz F, Krejci I, Barabakow F. Quality and durability of marginal adaptation in bonded composite restorations. Dent Mater 1991;7(2):107-113.
9. Rawls HR, Wellinghoff VT, Norling BK, Leamon SH, Swynnerton NF, Wellinghoff ST. Low shrinkage resins from liquid crystal diacrylate monomers. Polymer Preprints Am Chem Soc 1997;38:167-168.
10. Moszner N, Volkel T, Fischer U, Rheinberger V. Polymerization of cyclic monomers, part 8. Synthesis and radical polymerization of hybrid 2-vinylcyclopropanes. Macromol Rapid Comm 1999;20:33-35.
11. Smith RE, Pinzino CS, Chappelow CC, Holder AJ, Kostoryz EL, Guthrie JR, Miller M, Yourtee DM, Eick JD. Photopolymerization of an expanding monomer with an aromatic dioxirane. J Appl Polymer Sci 2004;92(1):62-71.
12. Guggenberger R, Weinmann W. Exploring beyond methacrylates. Am J Dent 2000;13(Special No):82D-84D.
13. Patent No. WO 98/22521. ESPE Dental AG, Seefeld, Germany, May 28, 1998.
14. Weinmann W, Luchterhandt T, Guggenberger R, Stippschild A, Then S, Dede K. Comparative testing of volumetric shrinkage and sealing of silorane and methacrylate filling materials. J Dent Res 2002;81(Special issue A), abstract No. 3382.
15. Feilzer AJ, De Gee AJ, Davidson CL. Setting stress in composite resin in relation to configuration of the restoration. J Dent Res 1987;66(11):1639-1639.
16. Eick JD, Smith RE, Pinzino CS, Kostoryz EL. Stability of silorane dental monomers in aqueous systems. J Dent 2006;34(6):405-410.
17. Arcari GM, Araújo E, Baratieri LN, Lopes GC. Microtensile bond strength of a nanofilled composite resin to human dentin after nonvital tooth bleaching. J Adhes Dent 2007;9(3):333-340.
18. Hashimoto M, Ohno H, Kaga M, Sano H, Tay FR, Oguchi H, Araki Y, Kubota M. Over-etching effects on micro-tensile bond strength and failure patterns for two dentin bonding systems. J Dent 2002;30(2-3):99-105.
19. Ilie N, Kunzelmann KH, Hickel R. Evaluation of micro-tensile bond strengths of composite materials in comparison to their polymerization shrinkage. Dent Mater 2006;22(7):593-601.
20. Van Ende A, De Munck J, Mine A, Lambrechts P, Van Meerbeek B. Does a low-shrinking composite induce less stress at the adhesive interface? Dent Mater 2010;26(3):215-222. Epub 2009 Nov 11. doi:10.1016/j.dental.2009.10.003.
21. Santini A, Miletic V. Comparison of the hybrid layer formed by silorane adhesive, one-step self-etch and etch and rinse systems using confocal micro-Raman spectroscopy and SEM. J Dent 2008;36(9):683-691.
22. Duarte S Jr, Phark JH, Varjao FM, Sadan A. Nanoleakage, ultramorphological characteristics, and microtensile bond strengths of a new low-shrinkage composite to dentin after artificial aging. Dent Mater 2009;25(5):589-600.
23. Duarte S Jr, Botta AC, Phark JH, Sadan A. Selected mechanical and physical properties and clinical application of a new low-shrinkage composite restoration. Quintessence Int 2009;40(8):631-638.
24. Peumans M, Kanumilli P, De Munck J, Van Landuyt K, Lambrechts P, Van Meerbeek B. Clinical effectiveness of contemporary adhesives: A systematic review of current clinical trials. Dent Mater 2005;21(9):864-881.
25. De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M, Van Meerbeek B. A critical review of the durability of adhesion to tooth tissue: Methods and results. J Dent Res 2005;84(2):118-132.

Manufacturers

Instron Corp., Canton, MA
800.564.8378, www.instron.com

KG Sorensen, Barueri, SP, Brazil
55.11.4197.1700, www.kgsorensen.com.br

Olympus America, Center Valley, PA
800.446.5967, www.olympusamerica.com

3M ESPE, St. Paul, MN
800.634.2249, solutions.3m.com

Treatment of gingival recession in two surgical stages: Free gingival graft and connective tissue grafting

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This report describes a clinical case of severe Miller Class II gingival recession treated by two stages of surgery that combined a free gingival graft and connective tissue grafting. First, a free gingival graft (FGG) was performed to obtain an adequate keratinized tissue level. Three months later, a connective tissue graft (CTG) was performed to obtain root coverage. The results indicated that the FGG allows for a gain in the keratinized tissue level and the CTG allows for root coverage with decreased recession level after 16 months. Therefore, for this type of specific gingival recession, the combination of FGG and CTG can be used.

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Root coverage is an important aim of periodontal therapy. There is a growing demand for this procedure in patients who require an improvement in their esthetic appearance.[1]

Gingival recession occurs when the gingival margin is apical to the CEJ; it results in exposed root surface and loss of both marginal tissue and attachment. The most frequent etiologic factors associated with gingival recession are inflammatory periodontal disease, traumatic toothbrushing, inadequate attached gingival dimensions, and iatrogenic factors.[2] Indications for root recession coverage are root sensitivity, root caries, difficulty in plaque control, an increase in the level of keratinized tissue, and undesirable esthetic results.[2] Periodontal surgery to restore esthetics, comfort, and function is one of the most common surgeries in clinical practice.[3]

A variety of surgical techniques have been developed to obtain root coverage. However, it has been determined that gingival recession can be treated successfully, regardless of the technique utilized.[4] Free gingival grafting (FGG), connective tissue grafts (CTG), coronally advanced flaps (CAF), and a combination of CTG, CAF, and guided tissue regeneration (GTR) have been introduced with a high degree of predictability in Miller Class I and II recession defects. A recent systematic review of the literature demonstrated that CTG, FGG, and CAF were effective in reducing gingival recession, with concomitant improvements in attachment level.[2] Another systematic review demonstrated that the CTG procedure optimizes results in root coverage and width of keratinized tissue.[5]

The aim of this case report was to evaluate the association of FGG and CTG performed in two different surgical stages to obtain root coverage.

Case report

The patient was a 31-year-old woman who was in good general health and did not smoke. She was taking no medications and had no contraindications for periodontal surgery. She had a history of periodontal disease, orthodontic therapy, and dental trauma in the central incisors.

The clinical probing depth was 2.0 mm, the recession level was 8.0 mm, and the width of the keratinized tissue was 0 mm (Table 1). Initial treatment consisted of oral hygiene instruction, dental adjustment, scaling with curettes, and professional cleaning using a rubber cup and a low-abrasive polishing paste. Surgical treatment of the recession defect was not

Table 1. Difference between baseline and 16-month measurements (in mm).

	FGG		CTG	
Parameter	Baseline	16 months	Baseline	16 months
Probing depth	2	2	2	2
Gingival recession	8	4	4	0
Keratinized tissue	0	4	4	8

Fig. 1. Preoperative aspect of the mandibular right central incisor. Note the absence of keratinized tissue.

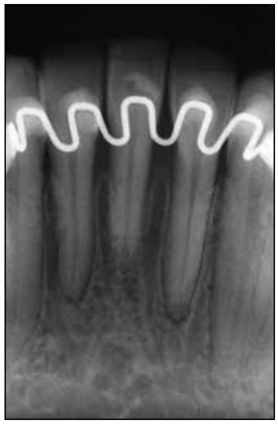

Fig. 2. Radiographic aspect showing the presence of interproximal alveolar bone.

Fig. 3. Root planing with curettes.

Fig. 4. Tetracycline being applied to the denuded root surface.

Fig. 5. Donor tissue was removed from the palatal area.

Fig. 6. After preparation of the recipient bed, an FGG was placed and sutured.

Fig. 7. One week after placement of the FGG.

scheduled until the patient demonstrated an adequate standard of plaque control.

An FGG was performed to gain widened keratinized tissue. The FGG, which was introduced by Bjorn in 1963, is a highly predictable technique used to increase the width of keratinized gingiva.[6-8]

After three months, an increase in keratinized tissue was observed. For this reason, a second surgical procedure was performed, involving a CTG placed in an envelope recipient bed. The CTG was removed from the palate using the single-incision palatal harvest technique referred to by Lorenzana and Allen.[9] The CTG was placed and secured through the envelope, covering the adjacent exposed root (Fig. 1–14). The FGG allows for a gain in the keratinized tissue level, while the CTG allows for root coverage with decreased recession level (Table 1).

Discussion

The introduction of FGG to obtain widened keratinized tissue and root coverage was a substantial development in esthetic periodontal surgery. Furthermore, using Miller's classification, knowledge of the marginal tissue recession etiology, risk factors, gingival biotypes, new approaches in surgical techniques, and the possible success of the root coverage resulted in increased performance of these procedures.[10]

The results of this case report support the theory that root coverage with FGG and CTG could produce an increase in root coverage and keratinized tissue. The defect in the current case was

Fig. 8. One month after placement of the FGG.

Fig. 9. Three months after the FGG was placed, a CTG was performed. An envelope technique was performed with a microsurgical blade.

Fig. 10. A partial thickness dissection was performed in the recipient bed.

Fig. 11. The connective tissue with underlying periosteum was carefully elevated and harvested from the palate.

Fig. 12. Immediately after positioning of the CTG.

Fig. 13. Healing at one week after the CTG.

Fig. 14. Complete root coverage was maintained at the 16-month follow-up.

classified as Miller Class II. Most of the soft tissue grafting techniques described previously have treated exposed root surfaces with CTG and/or modified, coronally advanced flap techniques.[4,11]

In the current case, an FGG was performed to increase keratinized tissue, while a CTG procedure was used to achieve root coverage. This two-stage surgical treatment plan involved deep recession in a thin, periodontal biotype and the total absence of keratinized tissue around the tooth. Initially, an FGG, such as that described by Bjorn (1963), was used to compensate for the lack of keratinized tissue. Partial root coverage was obtained with the FGG but was considered insufficient. To provide complete root coverage, a second procedure, involving an envelope technique with CTG (considered the gold standard), was necessary.[12]

In deep Miller Class II recession defects, as shown in the current case, abrupt movement of the flap in a coronal position to ensure major blood nutrition could cause a change in the gingival line, with undesirable vestibule loss. Moreover, with the high level of keratinized tissue obtained, the tissue became thicker, facilitating soft tissue management with a subsequent surgery and reflecting a higher success of the root coverage procedure.

It is important to note that both treatments (FGG and CTG) proved clinically successful with a high percentage of root coverage and keratinized tissue increase, and that the quantity and quality of the keratinized tissue could contribute to the long-term results of the root coverage. The current case includes issues of an absence of root sensitivity, patient oral hygiene compliance, and periodontal health.

Summary

Based on this case report, deep Miller Class II recession defects can be treated successfully when FGG is combined with CTG. However, randomized clinical trials involving patients with Miller Class II gingival recession defects are needed to confirm these findings.

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References

1. Zabalegui I, Sicilia A, Cambra J, Gil J, Sanz M. Treatment of multiple adjacent gingival recessions with the tunnel subepithelial connective tissue graft: A clinical report. Int J Periodontics Restorative Dent 1999;19(2):199-206.
2. Shin SH, Cueva MA, Kerns DG, Hallmon WW, Rivera-Hidalgo F, Nunn ME. A comparative study of root coverage using acellular dermal matrix with and without enamel matrix derivative. J Periodontol 2007;78(3):411-421.
3. Al-Zahrani M, Bissada N. Predictability of connective tissue grafts for root coverage: Clinical perspectives and a review of the literature. Quintessence Int 2005;36(8):609-616.
4. de Sanctis M, Zucchelli G. Coronally advanced flap: A modified surgical approach for isolated recession-type defects. Three-year results. J Clin Periodontol 2007;34(3):262-268.
5. Rocuzzo M, Bunino M, Needleman I, Sanz M. Periodontal plastic surgery for treatment of localized gingival recessions. A systematic review. J Clin Periodontol 2002;29 Suppl 3:178-194.
6. Bjorn H. Free transplantation of gingiva propria. Sven Tandlak Tidskr 1963;22:684.
7. Miller PD Jr. Root coverage using a free soft tissue autograft following citric acid application. Part I: Technique. Int J Periodontics Restorative Dent 1982;2(1):65-70.
8. Holbrook T, Ochsenbein C. Complete coverage of denuded root surface with a one-stage gingival graft. Int J Periodontics Restorative Dent 1983;3(3):8-27.
9. Lorenzana ER, Allen EP. The single-incision palatal harvest technique: A strategy for esthetics and patient comfort. Int J Periodontics Restorative Dent 2000;20(3):297-305.
10. Miller PD Jr. A classification of marginal tissue recession. Int J Periodontics Restorative Dent 1985;5(2):9-14.
11. Langer B, Langer L. Subepithelial connective tissue graft technique for root coverage. J Periodontol 1985;56(12):715-720.
12. Oates TW, Robinson M, Gunsolley JC. Surgical therapies for the treatment of gingival recession. A systematic review. Ann Periodontol 2003;8(1):303-320.

Hybrid layer thickness and morphology: Influence of cavity preparation with air abrasion

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Dentinal surfaces prepared with air abrasion have considerably different characteristics from those prepared with conventional instruments. Different hybrid layer morphology and thickness occur, which can result in differences in the quality of restorations placed on dentinal surfaces prepared with a diamond bur compared to surfaces prepared using air abrasion. The objective of this study was to compare the hybrid layer thickness and morphology formed utilizing Scotchbond Multi-Purpose Plus (SBMP) on dentin prepared with a diamond bur in a high-speed handpiece and on dentin prepared using air abrasion. Flat dentin surfaces obtained from five human teeth were prepared using each method, then treated with the dentin adhesive system according to manufacturer's instructions. After a layer of composite was applied, specimens were sectioned, flattened, polished, and prepared for scanning electron microscopy. Ten different measurements of hybrid layer thickness were obtained along the bonded surface in each specimen.

SBMP produced a 3.43 ± 0.75 µm hybrid layer in dentin prepared with diamond bur. This hybrid layer was regular and found consistently. In the air abrasion group, SBMP produced a 4.94 ± 1.28 µm hybrid layer, which was regular and found consistently. Statistical ANOVA ($P \leq 0.05$) indicated that there was a statistically significant difference between the groups. These data indicate that the air abrasion, within the parameters used in this study, provides a thick hybrid layer formation.

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One of the greatest challenges faced by dentistry today is to obtain an ideal restorative material. Characteristics of such a material include biocompatibility, fluoride release and recharge, adhesion to both enamel and dentin, esthetics, ease of use, and affordable cost. This quest has been facilitated by studies on enamel acid etchant development and studies on the hybrid layer development.[1,2]

The hybrid layer appears to play a critical role in adhesive dentistry. It has already been established that creating a high quality hybrid layer is very important, as it creates a barrier against demineralization caused by cariogenic agents.[3] Krejci *et al* have related that an adhesive system should promote a perfect marginal sealing, exhibit stability under the occlusal load, provide protection against secondary caries, and demonstrate marginal staining and post-treatment sensitivity.[4] According to these authors, there is a close relationship between the hybrid layer morphology and obtaining an excellent marginal seal.[4] Therefore, tests to evaluate an adhesive system should be carried out to evaluate the junction layer micromorphology and the hybrid layer thickness. A substantial amount of research regarding morphology evaluation and the hybrid layer thickness is already available.[5-9]

Perdigao *et al* stated that the dentinal substrate type could influence the adhesion mechanism and hybrid layer formation.[10] If this is true, the manner in which the adhesion substrate is prepared becomes critical; in other words, the preparation technique could influence the final restorative result. In studies evaluating preparation effectiveness, air abrasion has been compared favorably with conventional preparation methods using a high-speed turbine handpiece. Von Fraunhofer *et al* compared microleakage of composite restorations in teeth that were prepared conventionally with those prepared using air abrasion.[11] They concluded that there was no significant statistical difference between the groups, indicating that air abrasion had no significant influence on microleakage in adhesive filling procedures.

Other authors have conducted similar studies with different air abrasion parameters, with similar results.[12-17] Roeder *et al* compared the bond strengths of composite restorations in teeth prepared conventionally or with air abrasion, with 27 or 50 µm aluminium oxide particles.[12] Pamir and Turkun also compared microleakage of composite restorations.[16] In all of these studies, the use of air abrasion had no significant influence on the adhesive procedures. Another study evaluated the shear bond strength of glass-ionomer cements to air-abraded dentinal; the outcomes indicated an improvement in shear bonding of Fuji IX (GC America Inc.) after air abrasion treatment.[18]

On the other hand, some studies have found that dentinal surfaces prepared with air abrasion present characteristics that are quite different from those prepared with conventional rotary instruments.[19-21] These studies also have shown that different parameters will produce different tissue characteristics. The question then exists, how can it be possible to have similar adhesion results in different dentinal substrates?[12-21]

Based on this question, tests should be carried out to evaluate the junction layer micromorphology and the hybrid layer thickness to best evaluate an adhesive system. Krejci *et al* concluded that these tests also should evaluate a cavity preparation method.[4]

The objective of the present study was to compare the hybrid layers formed between an adhesive system and the dentin, developed using two different cavity preparation methods: a diamond bur in a high-speed handpiece, used as a control, and air abrasion.

Materials and methods

Five recently extracted mandibular molars were selected for the present study. All teeth were free from caries and previous restorations. The samples were cleaned with a periodontal curette, then cleaned with a fine flour of pumice using a rubber cup in a low-speed handpiece for 30 seconds. Samples were stored in distilled water at 37°C. The teeth were sectioned longitudinally in four parts by means of a mesiodistal cut and a faciolingual cut using a low-speed diamond saw (Isomet, Buehler) under a coolant water flow. After the initial sections were cut, the occlusal surface was removed by a horizontal cut with a low-speed diamond saw, 1.0 mm below the dentinoenamel junction.

The fragments were randomly divided into the following groups:

- **Group I—High-speed turbine (control; *n* = 5).** One section from each tooth was separated in an individual container containing distilled water and assigned a group number (A1–A5). A No. 1013 diamond bur (KG Sorensen) in a high-speed handpiece (KaVo America Corporation) under abundant water spray was used on the flattened occlusal surface of each section. The surface was prepared using random movements for 10 seconds to simulate the bottom of an occlusal cavity. One diamond bur was used for each dentin section.
- **Group II—Air abrasion (n = 5).** One section from each tooth was separated into an individual container containing distilled water and assigned a group number (B1–B5). Throughout the study, the numbering of each section corresponded to the same section in each group; for example, the section numbered *B1* in this group corresponds to *A1* in the previous group, and so on. The Mach 4.1 air abrasion device (Kreativ, Inc.) was used to irradiate the previously flattened occlusal dentin sections. Air abrasion was applied by means of a 45 degree handpiece kept at a standardized distance, fixed with an orthodontic thread fastened to the handpiece. Scanning movements were carried out at random during 30 seconds, simulating the bottom of an occlusal cavity prepared with air abrasion, according to the parameters described in Table 1.

Table 1. Kreativ Mach 4.1 air abrasion parameters.

Pressure	80 psi
Particle size	27 µm
Operation mode	Pulse
Operation distance	5.0 mm
Coolant	Air spray

After all occlusal surfaces had been prepared with either the diamond bur or air abrasion, all sections were conditioned with 37% phosphoric acid (Ivoclar Vivadent Inc.) for 15 seconds. The surfaces were rinsed with distilled water for 15 seconds, then gently dried with oil- and dust-free air for two seconds. Next, the Scotchbond Multi-Purpose Plus adhesive system (3M ESPE) was applied according to the manufacturer's instructions, as follows: A thin layer of the primer was applied with the help of a brush, then left undisturbed on the conditioned surfaces for 30 seconds. Next, the solvent was removed from the surface with oil- and dust-free air jets for five seconds, and a thin layer of the adhesive was applied. The adhesive layer was photocured for 20 seconds (intensity = 400 mW/cm^2, evaluated by means of a radiometer every 10 uses). A 1.0 mm thick, microhybrid composite layer (Fill Magic, Vigodent SA) in shade A1 with a unique increment was applied to all occlusal surfaces,

Table 2. Sample distributions.

Group	Cavity preparation method	Number of samples	Number of measurements
I	Diamond bur	5	50
II	Air abrasion	5	50
Total		10	100

Table 3. Hybrid layer thickness in Group I (diamond bur).

	Hybrid layer thickness (µm)									
Sample	1	2	3	4	5	6	7	8	9	10
A1	5.215	4.880	2.086	2.436	3.131	3.478	3.942	4.637	2.781	3.856
A2	2.552	3.538	2.544	2.300	3.410	4.635	2.604	3.710	3.345	4.023
A3	3.278	3.128	2.997	3.154	3.872	4.157	2.465	3.118	4.927	3.788
A4	2.665	3.600	3.477	3.015	3.245	3.592	3.592	4.404	4.410	3.824
A5	2.278	2.658	2.478	3.109	3.199	3.478	3.561	4.101	3.907	3.145

Note: Measurements 1–3 and 8–10 were taken in the outer part of the hybrid layer (three on each side); measurements 4–7 were taken in the central part of the hybrid layer.

Table 4. Hybrid layer thickness in Group II (air abrasion).

	Hybrid layer thickness (µm)									
Sample	1	2	3	4	5	6	7	8	9	10
B1	4.958	5.105	5.231	4.887	4.913	5.158	5.357	6.156	6.281	6.007
B2	6.491	6.378	5.332	5.447	4.757	5.247	4.968	6.730	5.100	5.868
B3	4.635	4.869	3.942	5.928	4.641	5.220	6.154	6.292	7.491	6.811
B4	2.436	1.970	3.838	2.747	3.525	2.127	4.545	4.729	5.458	6.893
B5	3.978	2.557	2.646	3.955	4.913	3.422	5.146	5.689	4.734	5.432

Note: Measurements 1–3 and 8–10 were taken in the outer part of the hybrid layer (three on each side); measurements 4–7 were taken in the central part of the hybrid layer.

which were then photocured for 40 seconds.[7]

After the samples were stored for seven days in distilled water, a transverse section was created 5.0 mm below the tooth/composite interface using a diamond saw (Isomet); next, the roots of the sections were separated and the remaining portion was sectioned longitudinally through the middle of the composite using the same diamond saw under abundant water spray. Two sections were obtained, formed by enamel and dentin, the adhesive system, and the microhybrid composite. The two sections were hand-polished using wet, 600-grit silicon carbide paper (Saint-Gobain Abrasives, Inc.) and a felt wheel placed in a polishing device (Praxis, TDV Dental). An alumina polishing paste (AP-Paste SQ, Struers Inc.) with 0.5 µm particles was used until no grooves were observed with a 50x magnifying glass. The sections again were conditioned in distilled water.

After seven days, one section of each previously formed pair was gently decalcified with 37% phosphoric acid for 10 seconds, rinsed with distilled water, then deproteinized with 3% sodium hypochlorite for 60 seconds.[7] Sections next were rinsed with distilled water, placed on aluminum stubs, and sputter-coated with gold (Edwards S150B, Edwards).

The samples were evaluated under a LEO 1450VP scanning electron microscope (LEO Electron Microscopy Group). Microphotographs of the hybrid layers were taken at standard magnifications (3,000x). Ten measurements were taken of the hybrid layer thickness of each sample, six measurements in the outer part of the hybrid layer (three on each side) and four in the central part of the same layer. These measurements were carried out using LEO-32 software (version 3.0, LEO Electron Microscopy Group), which is a component of the scanning electron microscope. This software allows measurements of distance between two points on an image with a 2% error margin. Table 2 shows distribution of the samples in the two groups in relation to cavity preparation modes and hybrid layer thickness measurements.

Results

The data derived from the two groups are shown in Table 3 (Group I, diamond bur) and 4 (Group II,

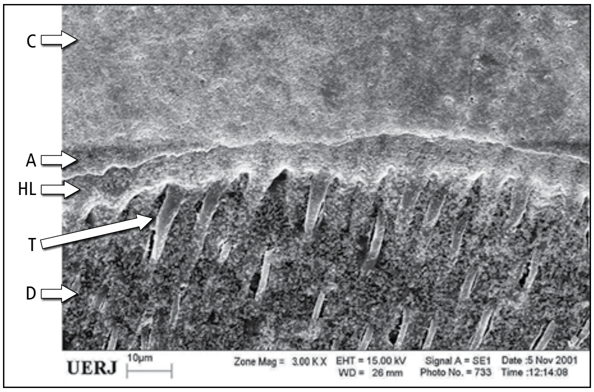

Fig. 1. Portion of hybrid layer formed in sample A1. C = composite; A = adhesive; HL = hybrid layer; T = adhesive tag; D = dentin.

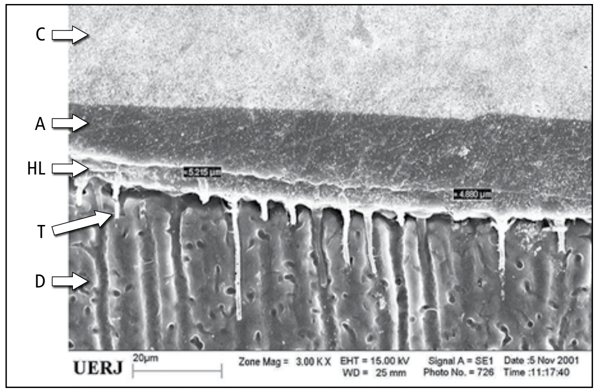

Fig. 2. Portion of hybrid layer formed in sample B1. C = composite; A = adhesive; HL = hybrid layer; T = adhesive tag; D = dentin.

air abrasion). The measurement data were statistically treated through the variance ANOVA using SPSS for Windows, version 5.0. The ANOVA ($P \leq 0.05$) showed a significant statistical difference between the combined effects of the two treatments. The Tukey and Student-Newman-Keuls tests ($P \leq 0.05$) separated the treatment into two homogenuous and distinct groups (Group I ≠ Group II). Table 4 shows the average results obtained in the two groups after statistical treatment. Figures 1 and 2 illustrate the differences between the hybrid layer thickness and morphology. These figures were obtained from fragments of the same tooth (samples A1 and B1).

Discussion

The high-speed handpiece is the primary method for cavity preparation in dentistry. Alternative methods for cavity preparation, including air abrasion, still have drawbacks, and preparations have yet to be standardized. A number of authors have recommended techniques and noted advantages for the use of air abrasion, with an emphasis on a reduction in pain, noise, and pressure, and have suggested the possible use of air abrasion in Class I–V direct restorations.[22,23] However, no one has recommended the use of air abrasion in indirect restorations, which require more defined cavity preparations. It is because of this limitation that the high-speed turbine remains the most commonly used method for cavity preparation.

Studies comparing microleakage data for adhesive restorations, performed in cavities treated with different preparation methods, are abundant in the dental literature; in general, all of the studied methods have presented statistically similar results.[11-13,24] Nonetheless, according to the descriptions by Krejci *et al,* tests that evaluate bonding forces only would be important for determining the quality of an adhesive system.[4] However, these studies should not be used as the sole or primary parameters for the recommendation of an adhesive system. According to these authors, a perfect marginal sealing would appear to be much more important; therefore, marginal adaptation tests would yield a greater clinical value.[4] These authors believe that there is a close relationship between hybrid layer morphology and a perfect marginal sealing, and that tests to evaluate the hybrid layer micromorphology and the hybrid layer thickness should always be carried out when evaluating adhesive system qualities.

The hybrid layer is extremely dependent on the dentinal substrate over which it is produced.[10] For this reason, the manner in which the dentin is prepared might be important. An earlier study indicated that preparations completed with air abrasion demonstrate a thick smear layer and present closed dentinal tubules after preparation; this is quite similar to preparations carried out with diamond points.[21]

The current study followed the methodology used by Ferrari *et al.*[6] The only exceptions to that study were in the dentinal substrate preparation method (diamond point and air abrasion) and the adhesive system used.[7]

In the current study, the authors decided to use tooth fragments, creating two groups, always originating from the same tooth, according to descriptions noted. The aim of this approach was to standardize the dentinal substrate where the superficial treatment had been performed, so that comparisons

Table 5. Mean results for both groups.

Group	Number of samples	Number of measurements	Mean thickness (µm)	Standard deviation
I	5	50	3.43	0.74
II	5	50	4.94	1.28

could be conducted using the same dentin pattern. This is in contrast with many other studies, in which experiments are carried out in multiple teeth, which could lead to exhibition of different dentin characteristics.

The average result analysis obtained in Group I (3.43 ± 0.74 µm) showed similarities to existing literature.[5,25-27] Those studies indicated, when using the adhesive system utilized in the current study, that the hybrid layer thickness average results varied between 3.0 µm and 5.0 µm.

A simple comparison between the average results obtained in Groups I (3.4 ± 0.74 µm) and II (4.94 ± 1.28 µm) demonstrates that air abrasion, within the parameters of the current study, allows for the formation of a thick hybrid layer when compared to the use of a diamond bur in a high-speed turbine. Table 5 shows that the groups were statistically heterogeneous, with Group II demonstrating greater thickness than Group I. However, much more important than the comparison between the obtained measurements was the fact that, in the samples in Group II, the hybrid layers were regular and found consistently and measurement was obtained more easily than those in Group I.

It was not possible to determine the cause of the results for Group II, either for the measurement results or their relation to the formation constancy. **The authors believe that the obtained results could be related to the following explanation from Barceleiro *et al:***

In the place where there is a perpendicular air abrasion incidence, no temperature increase would occur, promoting a less stressing alteration in the collagen fibers structure, when compared to the high-speed preparation (even under water coolant), leading to a regular and thick hybrid layer formation.[9]

Results from the present study showed that an association between air abrasion and the adhesive system used allowed for the formation of a thick hybrid layer that could have a positive effect on bonding and secondary caries prevention, according to Nakabayashi and Saimi and Krejci *et al.*[3,4] Additional studies are needed to include alterations in parameters used by the air abrasion device and in the adhesive system. Another suggestion would be to design studies that would try to explain the reasons for the differences found in the present study, repeating all of the parameters used here.

Conclusion

Through the analysis of results obtained in this *in vitro* study, it was possible to make the following conclusions:

- In dentin prepared with a diamond bur in a high-speed handpiece, the adhesive system produced hybrid layers with an average thickness of 3.43 ± 0.74 µm, with a consistent and regular format in a continuous way.
- In dentin prepared with air abrasion, the adhesive system produced hybrid layers with an average thickness of 4.94 ± 1.28 µm, with a consistent and regular format in a continuous way.
- The air abrasion preparation allowed for the formation of a thicker hybrid layer compared to the one formed after using a diamond bur in a high-speed handpiece.

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References

1. Buonocore MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. J Dent Res 1955;34(6):849-853.
2. Nakabayashi N, Kojima K, Masuhara E. The promotion of adhesion by the infiltration of monomers into tooth substrates. J Biomed Mat Res 1982;16(3):265-273.
3. Nakabayashi N, Saimi Y. Bonding to intact dentin. J Dent Res 1996;75(9):1706-1715.
4. Krejci I, Schupbach P, Balmelli F, Lutz F. The ultrastructure of a compomer adhesive interface in enamel and dentin, and its marginal adaptation under dentinal fluid as compared to that of a composite. Dent Mater 1999;15(5):349-358.
5. Ferrari M, Cagidiaco CM, Mason PN. Morphologic aspects of the resin-dentin interdiffusion zone with five different adhesive systems tested in vivo. J Prosth Dent 1994;71(4):404-408.
6. Ferrari M, Mannocci F, Kugel G, Garcia-Godoy F. Standardized microscopic evaluation of the bonding mechanism of NRC/Prime & Bond NT. Am J Dent 1999;12(2):77-83.
7. Nakajima M, Sano H, Urabe I, Tagami J, Pashley DH. Bond strengths of single-bottle dentin

adhesives to caries-affected dentin. Oper Dent 2000;25(1):2-10.
8. Barceleiro Mde O, de Mello JB, de Mello GS, Dias KR, de Miranda MS, Sampaio Filho HR. Hybrid layer thickness and morphology: Influence of cavity preparation with Er:YAG laser. Oper Dent 2005;30(3):304-310.
9. Barceleiro MO, Dias KR, Sales HX, Silva BC, Barceleiro CG. SEM evaluation of the hybrid layer after cavity preparation with Er:YAG. Oper Dent 2008;33(3):294-304.
10. Perdigao J, Swift EJ Jr, Denehy GE, Wefel JS, Donly KJ. *In vitro* bond strengths and SEM evaluation of dentin bonding systems to different dentin substrates. J Dent Res 1994;73(1):44-55.
11. von Fraunhofer JA, Adachi EI, Barnes DM, Romberg E. The effect of tooth preparation on microleakage behavior. Oper Dent 2000;25(6): 526-533.
12. Roeder LB, Berry EA 3rd, You C, Powers JM. Bond strength of composite to air-abraded enamel end dentin. Oper Dent 1995;20(5):186-190.
13. Nikaido T, Kataumi M, Burrow MF, Inokoshi S, Yamada T, Takatsu T. Bond strengths of resin to enamel and dentin treated with low-pressure air abrasion. Oper Dent 1996;21(5):218-224.
14. Hannig M, Femerling T. Influence of air-abrasion treatment on the interfacial bond between composite and dentin. Oper Dent 1998;23(5):258-265.
15. Aysegul O, Nurhan O, Haluk B, Dilek T. Microleakage of compomer restorations in primary teeth after preparation with bur or air abrasion. Oper Dent 2005;30(2):164-169.
16. Pamir T, Turkun M. Factors affecting microleakage of a packable resin composite: An *in vitro* study. Oper Dent 2005;30(3):338-345.
17. Silva PC, Goncalves M, Nascimento TN, Centola AL. Effect of air abrasion on tensile bond strength of a single-bottle adhesive/indirect composite system to enamel. Braz Dent J 2007; 18(1):45-48.
18. de Souza-Zaroni WC, Nhani VT, Ciccone-Nogueira JC, Chinelatti MA, Palma-Dibb RG, Corona SA. Shear bond strength of glass-ionomer cements to air-abraded dentin. J Adhes Dent 2006;8(4): 233-237.
19. Laurell KA, Hess JA. Scanning electron micrographic effects of air-abrasion cavity preparation on human enamel and dentin. Quintessence Int 1995;26(2):139-144.
20. Boston DW, Alperstein KS, Boberick K. Cavosurface margin geometry in conventional and air abrasion Class V cavity preparations. Am J Dent 1997;10(2):97-101.
21. Banerjee A, Kidd EA, Watson TF. Scanning electron microscopic observations of human dentine after mechanical caries excavation. J Dent 2000; 28(3):179-186.
22. Goldstein RE, Parkins FM. Air-abrasive technology: Its new role in restorative dentistry. J Am Dent Assoc 1994;125(5):551-557.
23. Radz GM. Air abrasion: The future of restorative microdentistry. Compend Contin Educ Dent 1997;18(6):534-540.
24. Goepferd S, Wilson RM. Comparison of microleakage for sealant bonding using air abrasion. J Dent Res 1997;76 (Spec Issue):63. Abstract 398.
25. Chappell RP, Cobb CM, Spencer P, Eick JD. Dentinal tubule anastomosis: A potential factor in adhesive bonding? J Prosth Dent 1994;72(2): 183-188.
26. Ferrari M, Davidson CL. *In vivo* resin-dentin interdiffusion and tag formation with lateral branches of two adhesive systems. J Prosthet Dent 1996;76(3):250-253.
27. Prati C, Chersoni S, Mongiorgi R, Montanari G, Pashley DH. Thickness and morphology of resin-infiltrated dentin layer in young, old, and sclerotic dentin. Oper Dent 1999;24(2):66-72.

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Severe oligodontia and dental anomalies in a child with a history of multiple natal teeth: An eight-year retrospective

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This article reports the case of a boy born with 11 natal teeth who had many alterations in his permanent dentition. In this case, 22 teeth were missing and a shape anomaly was detected in eight teeth. The treatment consisted of prosthetic rehabilitation and follow-up of teeth eruption and jaw growth.

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Hypodontia, which is the agenesis of one or more teeth, is the most common dental developmental anomaly.[1] It occurs in the permanent dentition in 3.5–6.5% of the population and is more prevalent in females.[2,3] Although tooth agenesis occasionally is caused by environmental factors, it has a genetic base in the majority of cases.[4] Many dental anomalies have been reported to be associated with tooth agenesis; these include small tooth size, peg-shaped teeth, and double tooth formation.[5,6] *Natal teeth* are teeth that are present at birth, while neonatal teeth erupt during the first 30 days following birth. The presence of natal teeth in newborns is uncommon and the majority represent the early eruption of normal primary teeth. The eruption of more than two natal teeth is considered rare.[7]

The correlation between these two alterations is rarely described in the literature. This article documents the case of a boy with severe hypodontia and shape anomalies in the permanent dentition associated with a history of 11 natal teeth.

Case report

An 8-year-old boy came to the Department of Pediatric Dentistry, Federal University of Rio de Janeiro, with a severe case of hypodontia (absence of 22 permanent teeth) and shape anomalies in eight teeth (Fig. 1 and Table 1). He was first brought to the clinic when he was 24 days old; at that time, his mother reported the presence of a rare condition of 11 natal teeth. Examination at the initial visit showed three natal teeth on the maxillary and mandible ridges that were subsequently extracted due to their extreme mobility. The other teeth had been removed at birth by the obstetrician, again due to extreme mobility and the risk of aspiration during feeding.[8] All teeth reflected standard primary dentition. A familial history of natal teeth, including the father and fraternal grandfather, was described, but the exact number of natal teeth in other family members was unknown.

The parents were recommended to a geneticist; however, the karyotype did not indicate any abnormalities. The child attended

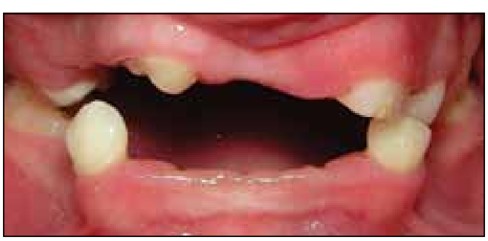

Fig. 1. Patient at age 5 years, 9 months.

Table 1. Dental anomalies noted in the present case.

Tooth number	Type of anomaly
2, 4, 6, 7, 10–13, 15, 18, 20–29, 31	Absent
3, 5, 8, 14, 19, 30	Anomaly of shape
9	Anomaly of shape with dens invaginatus

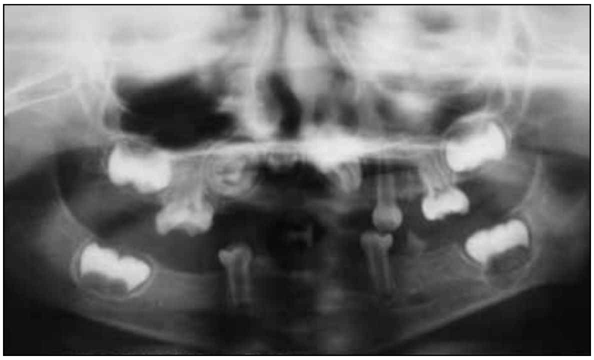

Fig. 2. Orthopantomograph at age 2 years, 9 months.

Fig. 3. New prosthesis that will be readjusted as the patient grows.

the clinic monthly for review of the eruption of the other teeth. The right maxillary molar (with anomaly in shape and hypoplasia) and left maxillary canine appeared at 23 months. At that time, both primary canines and the primary left premolar erupted with hypoplastic characteristics in the mandibular arch. The primary maxillary left molar erupted at 33 months. At this time, an orthopantomograph was obtained and other abnormalities and the absence of teeth from the permanent dentition were observed (Fig. 2). The permanent mandibular left premolar erupted at 43 months.

Treatment included reconstruction of the shape of the primary first premolar and prosthesis rehabilitation in an attempt to improve esthetics and function. The first prosthesis was created at 31 months and modified a year later due to nonadaptation; it had broken because of jaw growth and tooth eruptions. This prosthesis was readapted as necessary until the patient was 8 years old, when the anomalous teeth in the region of the maxillary right premolars were extracted and no more teeth would erupt. At that time, a new removable prosthesis was made (Fig. 3).

This patient will be treated until the jaw finishes growing; at that point, treatment will be carried out with implants and further prosthetic rehabilitation.

Discussion

Few studies in the current literature demonstrate associations of hypodontia, shape anomalies, and natal teeth. Lai and Seow described a rare congenital case of a healthy newborn and his mother, both of whom demonstrated multiple natal teeth and oligodontia. The baby had 12 teeth at birth, while the mother's dental records indicated that she had 16 teeth at birth.[9]

In the present case, the patient had a family history of both natal teeth and hypodontia. Some syndrome may be present, but only a karyotype genetic test was performed. For a more accurate diagnosis, specific genetic tests would be required; it is hoped that these would recognize any potential genetic alterations.

In cases of oligodontia in the anterior region, treatment must be well-planned, because it affects children's self-esteem and sociability. In the present case, the parents reported that the patient was very shy. da Silva *et al* observed that complaints were more frequent among children with missing anterior teeth; the same relationship was observed regarding satisfaction with prosthetic appliances by children and the region of the missing teeth.[10] After receiving the final prosthesis for this case, the patient was very happy, saying that now he could smile without embarrassment.

The patient will have to maintain close follow-up care to ensure that the prosthesis does not interfere with growth. The definitive treatment will be concluded only when the patient finishes growing. Treatment most likely will be multidisciplinary, involving specialists such as orthodontists, implantologists, and prosthodontists.

Summary

This report describes a rare case of a child born with multiple natal teeth associated with dental anomalies. Definitive treatment for such a case has not yet been described in the scientific literature because these abnormalities were found in a child who had no systemic changes or known genetic markers.

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References

1. Neville BWD DD, Allen CM, Bouquot JE. Alteracoes de desenvolvimento dos dentes. Patologia oral e maxillofacial, ed. 2 [in Portuguese]. Rio de Janeiro: Guanabara Koogan;2004: 68-70.
2. Zhu JF, Marcushamer M, King DL, Henry RJ. Supernumerary and congenitally absent teeth: A literature review. J Clin Pediatr Dent 1996; 20(2): 87-95.
3. Kuchler EC, Risso PA, Costa Mode C, Modesto A, Vieira AR. Studies of dental anomalies in a large group of school children. Arch Oral Biol 2008;53(10):941-946.
4. Arte S, Nieminen P, Apajalahti S, Haavikko K, Thesleff I, Pirinen S. Characteristics of incisor-premolar hypodontia in families. J Dent Res 2001;80(5):1445-1450.
5. Goldenberg M, Das P, Messersmith M, Stockton DW, Patel PI, D'Souza RN. Clinical, radiographic, and genetic evaluation of a novel form of autosomal-dominant oligodontia. J Dent Res 2000; 79(7):1469-1475.
6. Bateman G, Mossey PA. Ectopia or concomitant hypohyperdontia? A case report. J Orthodont 2006;33(2):71-77.
7. Leung AK, Robson WL. Natal teeth: A review. J Nat Med Assoc 2006 Feb;98(2):226-228.
8. Portela MB, Damasceno L, Primo LG. Unusual case of multiple natal teeth. J Clin Ped Dent 2004;29(1):37-39.
9. Lai PY, Seow WK. A controlled study of the association of various dental anomalies with hypodontia of permanent teeth. Pediatr Dent 1989;11(4):291-296.
10. da Silva VS, Barcelos R, de Souza IP. Perceptions of pediatric patients and guardians about prosthetic appliances. J Clin Ped Dent 2002;27(1): 87-90.