

Microleakage around Class V Composite Restorations after Ultrasonic Scaling and Sonic Toothbrushing around their Margin

RONALD E. GOLDSTEIN, DDS*, SURUCHI LAMBA, BDS†, NATHANIEL C. LAWSON, DMD, PhD‡, PRESTON BECK, MS†, ROBERT A. OSTER, PhD‡, JOHN O. BURGESS, DMD, MS†

ABSTRACT

Objectives: To measure microleakage around class V composite restorations after piezoelectric ultrasonic scaling and sonic toothbrushing.

Methods: 3 mm × 2 mm × 1.5 mm boxes were prepared on buccal and lingual surfaces of extracted molars centered on the cementum-enamel junction. Half the preparations were beveled (0.5 mm). Preparations were restored with composite and polished. Restorations on one side of the teeth were either traced with an ultrasonic scaler (60 seconds, $n = 16$) or brushed in a sonic toothbrushing machine (2 hours, $n = 16$). After thermocycling (10,000 cycles/5–55°C), specimens were immersed in 5 wt% Fuchsin solution (24 hours). Samples were sectioned and evaluated for percentage of dye penetration. Data were analyzed with an exact Wilcoxon rank-sum test and exact Wilcoxon signed-rank test ($\alpha = 0.05$).

Results: Microleakage was observed at the cementum-composite interface but not the enamel-composite interface. There was not a statistically significant effect of the bevel for ultrasonic scaling or for sonic toothbrushing. Data obtained with and without a bevel were combined and a statistically significant difference in microleakage between the treatment and control sides of the tooth were found for ultrasonic scaling ($32.5\% \pm 44.9\%$, $n = 16$; $p = 0.016$) but not sonic toothbrushing ($2.5\% \pm 41.2\%$, $n = 16$; $p = 1.0$).

Conclusions: Piezoelectric ultrasonic scaling increased microleakage at cementum-composite interface and there was no difference in microleakage with the use of a bevel.

CLINICAL SIGNIFICANCE

Piezoelectric sonic scaling around Class V composite restorations with margins in cementum should be avoided. Beveled margins will not reduce the incidence of microleakage resulting from ultrasonic scaling in Class V restorations. Placing the apical margin of the restoration in enamel should be attempted whenever possible to prevent future microleakage.

(J Esthet Restor Dent 29:41–48, 2017)

INTRODUCTION

Microleakage is a cause of restorative treatment failure. It is a dynamic phenomenon allowing the passage of

bacteria, oral fluids, molecules and ions through the interface of the restoration and cavity walls; however, in some cases, it is not clinically obvious.^{1,2} Presence and continuation of microleakage can cause secondary

*Department of Oral Rehabilitation, Augusta University Dental College of Georgia, Augusta, GA, USA.

†Division of Biomaterials, University of Alabama at Birmingham, Birmingham, AL, USA.

‡Department of Medicine, Division of Preventive Medicine, University of Alabama at Birmingham, Birmingham, AL, USA

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

caries, discoloration of restoration margins, hypersensitivity of the tooth and pulpal injury.^{3–5} It is a common problem associated with polymerization contraction stress and subsequent mechanical and thermal tensions, especially when the gingival margins extend below the cemento-enamel junction (CEJ). The bonding process is different for enamel than dentin or cementum because dentin and cementum are more humid, more dynamic and more organic than enamel. The higher organic component, tubular structure, fluid pressure, and permeability along with lower surface energy of dentin make bonding of the composite to dentin more difficult than to enamel.⁶ Due to reduced tooth loss in elders, more Class II and Class V lesions on root structure occur. In these situations, failure is usually seen in at the composite tooth interface, particularly for margins below the CEJ.^{7,8}

One fear of clinicians is that mechanical stimulation of the composite-tooth interface that occurs during hygiene procedures may disrupt their bond and lead to microleakage. Sources of this mechanical stimulation are sonic and ultrasonic scalers, which are used as effective tools for removing plaque and calculus from tooth and root surfaces.⁹ Sonic and ultrasonic scalers are differentiated based on the frequency at which the tips vibrate. Sonic scalers work by converting air-turbine pressure into 3,000 to 8,000 cycles per second (Cps) vibrations. Ultrasonic scalers generate ultrasonic tip vibrations from electrical input and can be divided between magnetorestrictive (18,000–45,000 Cps) and piezoelectric (25,000–50,000 Cps) units.¹⁰ Magnetorestrictive ultrasonic tips vibrate in an elliptical pattern and are active on all sides of the tip; whereas, piezoelectric tips vibrate in a linear motion and have two active sides of their tip. A laboratory study reported that a magnetorestrictive ultrasonic scaler had more adverse effects on the surface roughness of resin-based restorative materials than a sonic scaler.¹¹ Another laboratory study evaluated the microleakage caused by a magnetorestrictive ultrasonic cleaning device (Cavitron 660, Dentsply, Milford, DE) at the margins of a composite restoration and reported no statistical difference in microleakage from a control group.¹² Piezoelectric ultrasonic units have gained clinical favor due to quieter operation, smaller tips and

handpieces, and ease of use.¹³ Therefore, one aim of this study is to evaluate the effects of oscillations from a piezoelectric ultrasonic tip on the microleakage around a Class V restoration.

Toothbrush use may be another source of mechanical disruption of the composite-tooth interface. The use of powered toothbrushes has been shown to reduce plaque and gingivitis more than manual toothbrushing in the short and long term.¹⁴ Although no mode of action of powered toothbrush has been shown to be superior,¹⁵ sonic toothbrushes have claimed additional benefits of disrupting biofilm through acoustic vibration of fluid beyond the bristles. Sonic toothbrushes operate at 260 Cps.¹⁶ In a laboratory study, no difference was reported in the wear of composite materials subjected to manual and sonic toothbrushing.¹⁷ The second aim of this study to evaluate the effects of vibrations from a sonic toothbrush on the microleakage around a Class V restoration.

The purpose of this in vitro study is to determine if piezoelectric ultrasonic scaling or sonic toothbrushing will cause premature microleakage at the enamel or cementum margins of Class V composite restorations. Additionally, the effect of using a marginal bevel will be compared. The null hypotheses are: (1) there is no difference in microleakage following ultrasonic scaling treatment in composite restorations with and without a bevel, and (2) there is no difference in microleakage following sonic toothbrushing in composite restorations with and without a bevel.

MATERIALS AND METHODS

Following IRB approval, freshly extracted human molars ($n = 36$) were collected for this protocol. All teeth were evaluated using 20× magnification (VHX 600, Keyence, Osaka, Japan) and teeth with cracks and caries were excluded from the study. Standardized outlines (3 mm × 2 mm) were stamped and preparations made on the buccal and lingual surfaces of extracted human molars to position the occlusal margin in enamel and the apical margin in cementum.



FIGURE 1. Specimen preparation (from top left to bottom right): 3 mm × 2 mm stamp centered at CEJ, 1.5 mm deep preparation (unbeveled pictured), filled with composite and finished, covered with an acid resistant varnish.

Preparations were hand drilled to 1.5 mm in depth using a 557 carbide bur. Half of the specimens ($n = 16$) received a 0.5mm wide bevel surrounding the preparation. All preparations were restored using a resin composite (Filtek Supreme Ultra, 3M ESPE, St. Paul, MN, USA) placed with a bonding agent (Scotchbond Universal, 3M ESPE) in a total-etch mode. Specimens were etched (dentin and enamel) for 15 seconds with 37% phosphoric acid, rinsed for 10 seconds and lightly air-dried to leave dentin moist. One coat of bonding agent was applied and thoroughly scrubbed for 20 seconds and air evaporated for 10 seconds. The bonding agent was light polymerized with an Elipar S10 light curing unit (3M ESPE, 1100 mW/cm²) for 10 seconds. The composite was placed in a single increment and light polymerized for 20 seconds with the same light curing unit. All specimens were finished with a carbide finishing bur (OS-2, Brasseler, Savannah, GA, USA) and polished using polishing discs (Sof-Lex, 3M ESPE) from rough to fine (Figure 1). Restoration margins were evaluated under magnification after finishing and polishing to ensure the absence of “flash” over the margin.

Specimens were stored in water at 37°C for 24 hours. Specimens were then divided into two groups which received either ultrasonic scaling (beveled $n = 8$ and unbeveled $n = 8$) or sonic toothbrushing (beveled $n = 8$ and unbeveled $n = 8$) on one side of the tooth while the other side was left as a control.

Ultrasonic scaling was performed with a piezoelectric ultrasonic device (Varios 750, NSK-Nakanishi Inc, Kanuma, Japan) at full power with distilled water lubrication. A scaling tip (model G1, NSK-Nakanishi Inc) was used. The lateral side of the tip was placed in contact with the composite-tooth margin, and the margin was traced for 60 seconds. All specimens were scaled by the same operator who applied moderate hand pressure.

Sonic toothbrushing was performed in a custom toothbrushing device (Figure 2). The device contains four stations each mounted against a sonic toothbrush (Sonicare, Philips Sonicare, Bothell, WA, USA). The device applies 2 N of force and slides 2.3 mm at a frequency of 0.15 Hz. A solution of 8 g toothpaste

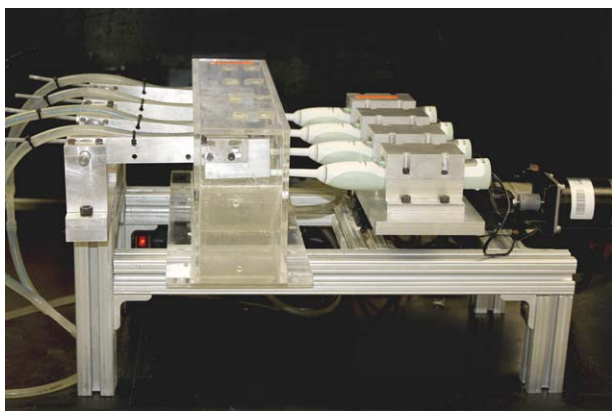


FIGURE 2. UAB toothbrushing device.

(Crest, Proctor & Gamble, Cincinnati, OH, USA) to 800 mL of water was circulated through the testing machine. The margins of the restorations on one side of the tooth were brushed in the device for 2 hours which simulates ~7 years. This time was calculated assuming ~1.4 seconds per tooth surface (2 minutes split occlusal, lingual, buccal for 28 teeth) and multiplying that by 2 times per day for ~7 years.

The root apices of all teeth were sealed with acrylic and two coats of acid-resistant varnish were applied to the teeth leaving an uncoated window including the restoration and 2mm of surrounding tooth structure (Figure 1). Specimens were then subjected to thermocycling with 10,000 cycles of alternating 5°C and 55°C water baths with 15 second dwell times. After thermocycling, samples were immersed in 5wt% solution of Fuchsin solution (Fischer Scientific Company, Fairlawn, NJ, USA) for 24 hours. Specimens were sectioned longitudinally through the center of the restorations with a dental sectioning disc (Vision flex diamond disc, Brasseler). The sections were then examined with a digital microscope (VHX 600, Keyence) at 30× magnification and dye penetration was quantitatively evaluated by measuring the distance of the dye penetration from the external surface with built-in image analysis software. Penetration was measured from the external surface to the point where no dye could be seen and reported in microns. Percentage microleakage was measured by dividing the linear distance of dye penetration by the linear distance from the external margin to the pulpal floor.

Descriptive statistics were calculated for the treatment and control sides of the tooth for beveled and unbeveled ultrasonic scaling, and for beveled and unbeveled sonic toothbrushing, as well as for the difference between the two sides of the tooth (treatment – control, representing the amount of the premature microleakage). Due to the small sample sizes and the non-normality of the distribution of the data to be analyzed, nonparametric statistical tests were performed. The beveled and unbeveled differences (unpaired data) for both the ultrasonic scaling and sonic toothbrushing were compared using the exact Wilcoxon rank-sum test and the treatment and control sides of the tooth (paired data) for both the ultrasonic scaling and sonic toothbrushing were compared using the exact Wilcoxon signed-rank test. Statistical tests were two-sided and used a significance level of 5%. SAS software (SAS Institute, Cary, NC, USA), version 9.4, was used to conduct the statistical analysis.

RESULTS

All microleakage was observed at the cementum-composite interface and no microleakage was observed at the enamel-composite interface. The results of the cementum-enamel microleakage are presented in Table 1. There was not a statistically significant effect of the bevel for ultrasonic scaling (beveled: mean \pm SD = 32.3% \pm 46.4%, $n = 8$; unbeveled: mean \pm SD = 32.8% \pm 46.6%, $n = 8$; $p = 1.0$) or for sonic toothbrushing (beveled: mean \pm SD = -2.5% \pm 45.0%, $n = 8$; unbeveled: mean \pm SD = 7.5% \pm 39.5%, $n = 8$; $p = 0.57$). Due to the lack of a statistically significant effect of the use of the bevel, we combined the data obtained from the use of the bevel with those obtained without the use of the bevel.

We then determined that there was a statistically significant difference in microleakage between the treatment and control sides of the tooth for ultrasonic scaling (mean \pm SD = 32.5% \pm 44.9%, $n = 16$; $p = 0.016$) but not for sonic toothbrushing (mean \pm SD = 2.5% \pm 41.2%, $n = 16$; $p = 1.0$). Representative specimens from each group are shown in Figure 3.

TABLE I. Percent microleakage at cementum-composite interface

Marginal bevel	Treatment group	Microleakage (mean \pm SD)	Microleakage (Range)
Beveled	Ultrasonic scaling	100 \pm 0.0%	100–100%
	Ultrasonic scaling control	67.8 \pm 46.4%	0–100%
	Sonic toothbrushing	63.1 \pm 36.3%	10–100%
	Sonic toothbrushing control	65.6 \pm 38.3%	10–100%
Unbeveled	Ultrasonic scaling	97.9 \pm 6.01%	83–100%
	Ultrasonic scaling control	65.1 \pm 44.3%	0–100%
	Sonic toothbrushing	38.8 \pm 46.0%	0–100%
	Sonic toothbrushing control	31.3 \pm 40.2%	0–100%

DISCUSSION

The results of this study demonstrate that piezoelectric ultrasonic scaling a cementum-composite margin may lead to increased microleakage. Sonic toothbrushing,

however, did not lead to increased microleakage. No leakage was noted at the enamel-composite margin and no difference was seen in the microleakage between beveled and unbeveled margins. The clinical significance of these results is that piezoelectric

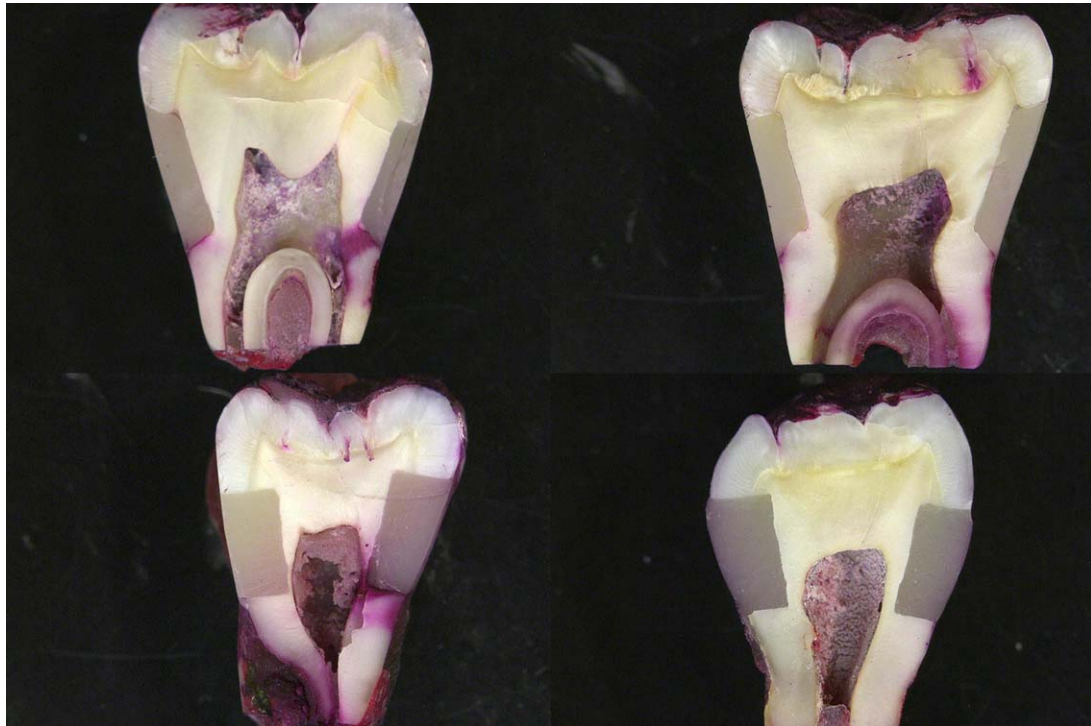


FIGURE 3. Representative sectioned specimens with control on left and treatment on right (from top left to bottom right): Beveled ultrasonic scaling group, beveled sonic toothbrushing group, unbeveled ultrasonic scaling group, unbeveled sonic toothbrushing group.

ultrasonic scaling around Class V composite restorations with margins in cementum should be cautioned. Hand instrumentation will likely induce less mechanical damage to the cementum-composite interface. For Class V composite restorations, beveled margins will not reduce the incidence of microleakage resulting from ultrasonic cleaning. Placing the apical margins of the restoration in enamel should be attempted when possible to prevent future microleakage.

This study attempted to mimic clinical conditions, however, some variables that were not accounted for may have underrepresented the amount of dye penetration. Since all preparations were finished and polished extra-orally there was complete access to all margins and no flash or overhangs were present. In the clinical situation, gingival tissue often obstructs the operator's ability to finish or polish the restoration. Composite overhangs or positive steps in the restoration may serve as a mechanical catch that could increase the mechanical force applied to margin and expedite marginal deterioration. Areas of thin composite flash at the margin could be susceptible to chipping from the force of the ultrasonic scaler leading to plaque accumulation and eventually secondary caries. Occlusal forces are an etiology of cervical lesions, therefore, simulated occlusal loading has been shown to expedite microleakage.^{18,19} However, another previous study reported that occlusal loading did not change dye penetration.²⁰ A major limitation of the study was that only one operator performed all of the ultrasonic scaling. Differences in applied pressure, motion of the tip, and angle of the tip relative to the restoration employed by different operators may all affect the severity of resultant microleakage. Additional research may evaluate the effect of microleakage with different applied pressures.

Observation of the sectioned teeth reveals that microleakage in several of the teeth extended from the external surface of the restoration to the internal pulpal floor (Figure 3). As ultrasonic scaling occurs only at the surface of the restoration, the action of the sonic scaler likely initiated a marginal opening

that was propagated through the forces applied to the composite interface during thermocycling. A previous study reported that thermocycling between 5 and 55°C for 500 cycles significantly increase microleakage in Class V restorations,²¹ however, other studies have reported no effect of thermocycling on microleakage.^{22,23} Theoretically, the greater coefficient of thermal expansion of dental composite than enamel or dentin leads to thermally induced stresses.²⁴ Some of the control restorations had cementum-composite margins with microleakage extending to the pulpal floor. For these teeth, the polymerization shrinkage stresses likely induced marginal opening leading to microleakage.²⁵

A previous study of the effect of magnetorestrictive ultrasonic scaling on Class V composite restorations found no statistical difference in the microleakage of control and treated teeth on the enamel or cementum margin.¹² In that study, 40% of the control and 60% of the treated specimens had significant microleakage at the cementum margin, whereas, none of the control specimens and 10% of the treated specimens had significant microleakage at the enamel margin. In order to give a dependable comparison between the microleakage caused by magnetorestrictive and piezoelectric ultrasonic scalers, a study with types of ultrasonic scalers using the same operator and testing conditions should be performed.

The clinical relevance of microleakage testing has been questioned due to the lack evidence correlating *in vitro* staining with clinical parameters.²⁶ Additionally, the small size of the molecular tracers used to detect microleakage may allow them to penetrate spaces smaller than bacterial penetration. Although difference tracers have been used for microleakage studies, two of the most common, fuschin and sliver nitrate, show acceptable correlation with SEM evaluation of dentin marginal adaptation.²⁷ Additional clinical correlations are necessary to further validate this method of assessment. Future studies should also examine the effects of sonic scaling on the microleakage caused around cemented and bonded fixed prostheses.

CONCLUSION

Under the limitations of the study, piezoelectric ultrasonic scaling increased microleakage at cementum-composite interface but not the enamel-composite interface. Sonic toothbrushing had no effect on microleakage. There was no difference in microleakage with the use of a bevel.

DISCLOSURE AND ACKNOWLEDGEMENTS

The authors do not have any financial interest in the companies whose materials are included in this article. The authors would like to acknowledge the Foundation Research Grant from the Alpha Omega Dental Foundation for the support of this research project. Statistical analysis of research reported in this publication was partially supported by National Center for Advancing Translational Sciences of the National Institutes of Health under award number UL1TR001417.

REFERENCES

- Kidd EA, Beighton D. Prediction of secondary caries around tooth-colored restorations: a clinical and microbiological study. *J Dent Res* 1996;75:1942–6.
- Alani AH, Toh CG. Detection of microleakage around dental restorations: A review. *Oper Dent* 1997;22:173–85.
- Mantri SP, Mantri SS. Management of shrinkage stresses in direct restorative light-cured composites: a review. *J Esthet Restor Dent* 2013;25:305–13.
- Calheiros FC, Sadek FT, Braga RR, et al. Polymerization contraction stress of low-shrinkage composites and its correlation with microleakage in Class V restorations. *J Dent* 2004;32:407–12.
- Sultan A, Moorthy A, Fleming GJ. The adhesive potential of dentin bonding systems assessed using cuspal deflection measurements and cervical microleakage scores. *Dent Mater* 2014;30:1154–60.
- Ghavannasiri M, Moosavi H, Tahvildarnejad N. Effect of centripetal and incremental methods in Class II composite resin restorations on gingival microleakage. *J Contemp Dent Pract* 2007;8:113–20.
- Ferrari M, Cagidiaco MC, Davidson CL. Resistance of cementum in Class II and V cavities to penetration by an adhesive system. *Dent Mater* 1997;13:157–62.
- Ferrari M, Mason PN. Adaptability and microleakage of indirect resin inlays: an in vivo investigation. *Quintessence Int* 1993;24:861–5.
- Drisko CL, Cochran DL, Blieden T, et al. Position paper: sonic and ultrasonic scalers in periodontics. Research, science and therapy committee of the American academy of periodontology. *J Periodontol* 2000;71:1792–801.
- Arabaci T, Çiçek Y, Canakçi CF. Sonic and ultrasonic scalers in periodontal treatment: a review. *Int J Dent Hyg* 2007;5:2–12.
- Lai YL, Lin YC, Chang CS, et al. Effects of sonic and ultrasonic scaling on the surface roughness of tooth-colored restorative materials for cervical lesions. *Oper Dent* 2007;32:273–8.
- Gorfil C, Nordenberg D, Liberman R, et al. The effect of ultrasonic cleaning and air polishing on the marginal integrity of radicular amalgam and composite resin restorations. An in vitro study. *J Clin Periodontol* 1989;16:137–9.
- Voller RJ. Ultrasonic scalers: clinical use and benefits. *Dent Today* 2006;25:82–84.
- Yaacob M, Worthington HV, Deacon SA, et al. Powered versus manual toothbrushing for oral health. *Cochrane Database Syst Rev* 2014;6:CD002281.
- Deacon SA, Glenny AM, Deery C, et al. Different powered toothbrushes for plaque control and gingival health. *Cochrane Database Syst Rev* 2010;12:CD004971.
- Johnson BD, McInnes C. Clinical evaluation of the efficacy and safety of a new sonic toothbrush. *J Periodontol* 1994;65:692–7.
- Donly KJ, Vargas M, Meckes M, et al. In vitro comparison of restoration wear and tensile strength following extended brushing with Sonicare and a manual toothbrush. *J Clin Dent* 1997;8(1 Spec No):30–5.
- Arisu HD, Uçtasli MB, Eligüzeloğlu E, et al. The effect of occlusal loading on the microleakage of class V restorations. *Oper Dent* 2008;33:135–41.
- Davidson CL, Abdalla AI. Effect of occlusal load cycling on the marginal integrity of adhesive Class V restorations. *Am J Dent* 1994;7:111–4.
- Pongprueksa P, Kuphasuk W, Senawongse P. Effect of elastic cavity wall and occlusal loading on microleakage and dentin bond strength. *Oper Dent* 2007;32:466–75.
- Wahab FK, Shaini FJ, Morgano SM. The effect of thermocycling on microleakage of several commercially available composite Class V restorations in vitro. *J Prosthet Dent* 2003;90:168–74.
- Wendt SL, McInnes PM, Dickinson GL. The effect of thermocycling in microleakage analysis. *Dent Mater* 1992;8:181–4.
- Prati C, Tao L, Simpson M, et al. Permeability and microleakage of Class II resin composite restorations. *J Dent* 1994;22:49–56.

24. Versluis A, Douglas WH, Sakaguchi RL. Thermal expansion coefficient of dental composites measured with strain gauges. *Dent Mater* 1996;12:290–4.
25. Ferracane JL, Mitchem JC. Relationship between composite contraction stress and leakage in Class V cavities. *Am J Dent* 2003;16:239–43.
26. Heintze SD. Clinical relevance of tests on bond strength, microleakage and marginal adaptation. *Dent Mater* 2013; 29:59–84.
27. Heintze S, Forjanic M, Cavalleri A. Microleakage of Class II restorations with different tracers—comparison with SEM quantitative analysis. *J Adhes Dent* 2008;10: 259–67.

Reprint requests: Ronald Goldstein, DMD, 600 Galleria Pkwy Suite 800, Atlanta, GA 30339, USA; Tel.: 404-261-4941; Fax: 404-261-4946; email: esthetics@mindspring.com