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Influence of an Intermediary Base on the Microleakage of Simulated Class II Composite Resin Restorations

MCC Giorgi • NMAP Hernandes • MM Sugii
GMB Ambrosano • GM Marchi • DANL Lima
FHB Aguiar

Clinical Relevance

The use of resin-modified glass ionomer cement as an intermediary base provides lower microleakage, indicating better sealing of the tooth-restoration interface.

Maria Cecília C Giorgi, DDS, MS, PhD, Department of Restorative Dentistry, Piracicaba Dental School, University of Campinas, São Paulo, Brazil

Natália MAP Hernandes, DDS, MS, PhD student, Department of Restorative Dentistry, Piracicaba Dental School, University of Campinas, São Paulo, Brazil

Mari M Sugii, DDS, MS student, Department of Restorative Dentistry, Piracicaba Dental School, University of Campinas, São Paulo, Brazil

Glaucia MB Ambrosano, MS, PhD, Community Dentistry Department, Piracicaba Dental School, University of Campinas, São Paulo, Brazil

Giselle M Marchi, DDS, MS, PhD, Department of Restorative Dentistry, Piracicaba Dental School, University of Campinas, São Paulo, Brazil

Débora ANL Lima, DDS, MS, PhD, Department of Restorative Dentistry, Piracicaba Dental School, University of Campinas, São Paulo, Brazil

*Flávio HB Aguiar, DDS, MS, PhD, Department of Restorative Dentistry, Piracicaba Dental School, University of Campinas, São Paulo, Brazil

*Corresponding author: Av Limeira, 901, Piracicaba, São Paulo 13414903, Brazil; e-mail: aguiar@fop.unicamp.br

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SUMMARY

The aim of this *in vitro* study was to qualitatively and quantitatively evaluate the microleakage of Class II cavities restored with a methacrylate-based composite (Filtek Z250, 3M ESPE) or silorane-based composite (Filtek LS, 3M ESPE), varying the application of an intermediary base, using a low-viscosity composite resin (Filtek Z350 Flow, 3M ESPE) or resin-modified glass ionomer cement (RMGIC) (Vitrebond, 3M ESPE) and no intermediary base (control groups). Sixty cavities were prepared on the proximal surfaces of bovine teeth and were randomly divided according to the experimental groups (n=10). Following the restorative procedures and thermocycling, the samples were immersed in methylene blue for two hours. The qualitative evaluation was made using a stereomicroscope, whereby two observers analyzed the infiltration level of the dye within the tooth/filling. Microleakage scores among the groups were compared using the Kruskal-Wallis test followed by the Mann-Whitney test ($p \leq 0.05$). The samples were then

ground and the powder was prepared for quantitative analysis in an absorbance spectrophotometer. The results were statistically analyzed by analysis of variance and the Tukey test ($p \leq 0.05$). Results from the quantitative analysis showed that LS presented higher values of microleakage than did Z250. There was a significant difference between both composites concerning the intermediary materials, with the lowest values obtained using RMGIC as an intermediary base. Results from the qualitative analysis showed that there were no statistically significant differences between composites; however, there were significant differences for both composites concerning the intermediary materials, with the lowest values obtained using RMGIC as an intermediary. It is possible to conclude that using RMGIC as an intermediary base provided lower microleakage, indicating better sealing of the tooth-restoration interface.

INTRODUCTION

The polymerization reaction for methacrylate resin-based composites occurs through the conversion of monomer molecules into a structure of cross-linked polymers.[1] The main adverse effect of this material is volumetric shrinkage, which contributes to stress formation along the bonded interfaces of restorations[2] as well as to the formation of gaps in the composite-dentin interface, initiating the microleakage process.[3] Microleakage is defined as the passage of bacteria, fluids, or molecules between a cavity wall and the restorative material applied to it, and microleakage may cause hypersensitivity, recurrent caries, and pulpal pathoses.[4,5]

To reduce the side effects caused by polymerization shrinkage stress, an intermediary layer between the composite resin and the tooth has been proposed[3] as an alternative to creating a tooth-restoration interface without the presence of gaps. Studies have suggested using materials, such as flowable composite resins,[6] to act as a stress-absorbing layer, relieving the stress generated during polymerization shrinkage and promoting more effective sealing to the tooth structure. Resin-modified glass ionomer cements (RMGICs) have also been recommended as a base material, because they replace some of the composite volume and reduce the side effects of polymerization shrinkage.[7]

Recently, a new silorane-based composite resin has been introduced that has a distinctive polymerization characteristic that reduces polymerization shrinkage.[8] Silorane was so named by the manufacturer to indicate a hybrid compound of siloxane and oxirane functional moieties.[2] The silorane matrix is formed by a cationic ring opening of the silorane monomers during polymerization instead of free-radical polymerization of methacrylate monomers.[9] Therefore, a significantly lower polymerization shrinkage and lower stress development occur.[10] However, little is known about the effect associating an intermediate material and a silorane-based composite.

This current study compared the microleakage of Class II restorations restored with methacrylate- or silorane-based resins and different intermediary base materials. The null hypotheses were 1) there is no difference between marginal infiltration of methacrylate- and silorane-based restorations; and 2) there is no difference between the marginal infiltration of composite restorations when using different base materials.

MATERIALS AND METHODS

Sixty extracted bovine incisors were collected, cleaned with a periodontal curette, polished with a Robinson brush and pumice paste under water, and then stored in distilled water until they were used. The tooth had part of its root embedded in cold-cure polystyrene resin (Piraglass, Piracicaba, SP, Brazil). The specimens were then split obliquely 6 mm from the dentino-enamel proximal junction using a double-faced diamond disc (KG Sorensen, Barueri, SP, Brazil). After cutting, the incisal surfaces were finished with 600-grit water-abrasive papers to obtain a smooth surface.

Specimen Preparation

Cavities were made using a diamond tip #3146 (KG Sorensen) coupled to a cavity preparation unit on the flattest proximal surface, simulating a Class II restoration, measuring 6 mm high, 4 mm wide, and 1.5 mm deep, under irrigation with an air/water jet. The cervical limit of the proximal box was 1 mm above the cemento-enamel junction. The burs were replaced after every five preparations. The cavities were randomly restored, with one of the following six techniques.

Group 1—Filtek Z250 (3M ESPE, St Paul, MN, USA): The cavities were etched for 30 seconds in enamel and 15 seconds in dentin, using 37% phosphoric acid (3M ESPE), washed for 30 seconds, and gently dried with filter paper to prevent excessive dentin drying. The adhesive system Adper

Single Bond 2 (3M ESPE) was applied in two consecutive coats for 15 seconds with gentle agitation, gently air-dried for 10 seconds, and then light-cured for 10 seconds. The composite was inserted incrementally (2-mm horizontal increments), and each increment was light-cured for 20 seconds.

Group 2—Filtek LS (3M ESPE): The self-etching primer, LS Primer (3M ESPE), was applied in one coat for 15 seconds with gentle agitation, gently air-dried for 10 seconds, and then light-cured for 10 seconds. LS Bond was applied, gently air-dried for 10 seconds, and light-cured for 10 seconds. The composite was inserted incrementally (2-mm horizontal increments), and each increment was light-cured for 20 seconds.

Group 3—Filtek Z350 flow (3M ESPE)/Filtek Z250: The same restorative protocol described for group 1 was performed; however, the low-viscosity version of the resin was applied on the gingival wall up to the dento-enamel junction with a 2-mm thickness before inserting Filtek Z250 and light-curing for 20 seconds.

Group 4—Filtek 350 flow/Filtek LS: The same restorative protocol described for group 2 was performed; however, the low-viscosity version of the resin was applied on the gingival wall up to the dento-enamel junction with a 2-mm thickness prior to the application of LS Bond and light-cured for 20 seconds.

Group 5—Vitrebond (3M ESPE)/Filtek Z250: A RMGIC was applied on the gingival wall up to the dento-enamel junction, in a 2-mm thickness, and was light-cured for 40 seconds. After that, the same restorative protocol described for group 1 was performed.

Group 6—Vitrebond/Filtek LS: A RMGIC was applied on the gingival wall up to the dento-enamel junction, in a 2-mm thickness, and was light-cured for 40 seconds. After that, the same restorative protocol described for group 2 was performed.

A Bluephase 16i light-curing unit (Vivadent, Bürs, Austria) with an irradiance of 1100 mW/cm^2 was used to photoactivate all groups. The tip of the light-curing unit was positioned perpendicular to the incisal surface of the tooth without touching it.

After 24 hours of storage at 37°C the restorations were finished and polished with Sof-Lex Pop-on aluminum oxide disks (3M ESPE) in decreasing order of granulation. The samples were thermocycled 1000 times (5±2°C, 37±2°C, and 55±2°C) with a dwell time of one minute each at each temperature and a transfer interval of five seconds (MSCT, 3 PLUS, São Carlos, SP, Brazil).

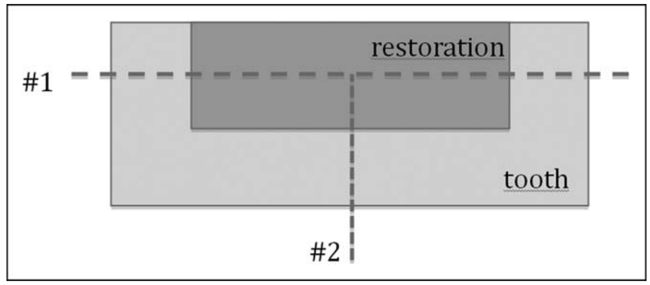

Figure 1. *The fragments for qualitative analysis were obtained by the sectioning of the tooth-restoration block in three parts. The first cut (#1) was made in the center of the tooth-restoration block in the mesio-distal direction, resulting in two segments (upper and lower). After that, the lower segment was also sectioned in half, now in the gingival-occlusal direction (#2). Obtaining fragments with approximate areas of microleakage was possible because of the prior standardization of the dimensions of the cavity.*

Dye Immersion

After these procedures, the entire sample (except for the cervical interface between the restoration and the tooth) was protected with two layers of fast-setting Superbonder cyanoacrylate-based adhesive (Henkel Loctite Adesivos, Itapevi, SP, Brazil). Before dye immersion, a 1-mm strip of adhesive tape (Fix-Baby, Embalando, Fitas Adesivas Ltda, Arujá, SP, Brazil) was placed around the area that was infiltrated, and two layers of nail varnish were applied. Then the tape was removed, the interface was cleaned with sterile gauze, and the specimens were totally immersed in 2% neutral methylene blue solution for two hours. The blocks were then removed from the dye solution, washed under running water, and dried. The nail varnish was removed using a periodontal curette, and the dye on the restoration was removed up to 0.05 mm from the surface, as controlled by a caliper.

Fragments

Three fragments were obtained for qualitative analysis, named "left wall," "gingival wall," and "right wall" (Figure 1).

Qualitative Analysis

The qualitative evaluation was performed by two previously calibrated examiners under a stereomicroscope at 40× magnification. The specimens were evaluated using the following microleakage scores: 0 = no infiltration; 1 = infiltration within tooth/material interface, beyond half of the gingival wall; 2 = infiltration within tooth/material interface, beyond half of the gingival wall, but not reaching the axial wall; and 3 = infiltration within tooth/material interface up to or beyond axial wall (ISO 11405:2003).

Quantitative Analysis: Sample Trituration

To take a reading of the infiltrated dye color, specimens (dental block + restoration) were weighed. After weighing, the specimens were triturated in a hard fabric grinder (MA-475, Marconi Equip Ltda, Piracicaba, SP, Brazil) in order to obtain a powder composed of the tooth/restoration and were then weighed again. If the difference between the initial and final weights was greater than 10%, the specimen was discarded. In this present study, no specimens were discarded.

Dissolution

After trituration, the powder obtained from each sample was separately immersed in a test tube containing 4 mL of absolute alcohol PA for 24 hours to dissolve the dye that leaked through the tooth/restoration interface. The solution obtained was centrifuged at 3000 rpm for three minutes so that the powder and other elements separated. The supernatant of the centrifuged solution was submitted to quantitative analysis of the dye present in the solution with a spectrophotometry unit (Beckman DU-65 Instruments Inc, Fullerton, CA, USA) using absorbance reading.

The absorbance reading was taken in an adjusted unit at a wavelength of 668 nm, corresponding to the maximum absorbance of methylene blue dye. Prior to the readings, the spectrophotometry unit had been adjusted by spectral reading with pattern solutions at concentrations of 0.1; 0.2; 0.3; 0.5; 1; 2; 4; and 6 μg/mL to obtain the maximum spectral absorbance wavelength. Readings of the solutions were made using the wavelength value to find the maximum value of spectral absorbance. By using the ABS-concentration system, the r^2 value (0.9999) is obtained and the equation of the line is (y=a+bx). The following regression was obtained: absorbance = 0.22759 × (dye concentration) + 0.0011. From this regression, dye concentration can be calculated. A graph of lines in a Cartesian system of axes was drawn, using the values of dye concentration in micrograms per milliliters on the axis of the abscissas and the optical density obtained on the axes of the ordinates. The linear regression was obtained from Y as a function of X to determine the equation of the line, from which the concentration of dye was calculated.

Table 1: *Results of Quantitative Microleakage (Standard Deviation [SD])*[a]

	Composite	
	LS Mean (SD)	Z250 Mean (SD)
No intermediary base	0.103 (0.221) Aa	0.021 (0.020) Ba
RMGIC	0.015 (0.024) Ab	0.007 (0.007) Bb
Flow	0.034 (0.023) Aa	0.018 (0.016) Ba

Abbreviation: RMGIC, resin-modified glass ionomer cement.
[a] *Means followed by distinct letters (capital letters in the horizontal and lowercase letters in the vertical) differ between them ($p<0.05$).*

The microleakage data of experimental groups was submitted to three-way analysis of variance and Tukey test for quantitative analysis. For qualitative analyses, the Kruskal-Wallis test was used to assess the differences within the groups. The Mann-Whitney *U*-test was used to investigate the pairwise differences among the different groups. The level of statistical significance was set at 5%.

RESULTS

Results from the quantitative analysis are presented in Table 1 and Figure 2. Filtek Z250 showed significantly lower (69.8%) microleakage means when compared to Filtek LS. For both composite resins, the groups with RMGIC used as a base showed significantly lower (82.3% for no intermediary base; 57.7% for the flow) means than the other groups.

Results from the qualitative analysis are shown in Table 2. There was no statistically significant difference between composites. For both composites, there was a significant difference among the intermediary materials, with the lowest values obtained with the RMGIC base. Table 3 and Figure 3 present results from the quantitative analysis discriminated

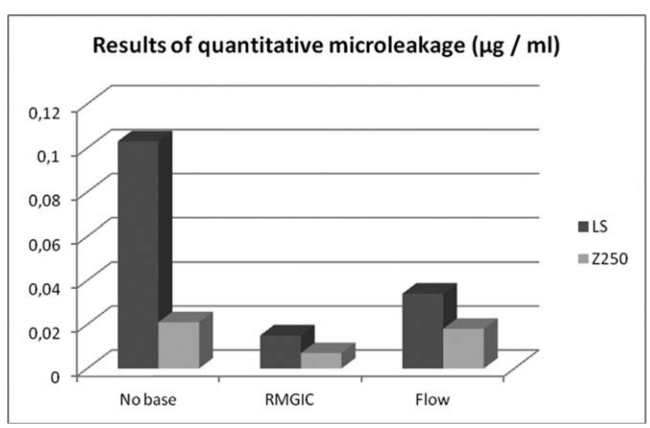

Figure 2. *Results of quantitative microleakage.*

Table 2: *Results of Qualitative Microleakage*[a]

	Composite	
	LS Median	Z250 Median
No intermediary base	3.00 Aa	2.00 Ab
RMGIC	1.00 Ab	1.00 Ab
Flow	3.00 Aa	3.00 Aa

Abbreviation: RMGIC, resin-modified glass ionomer cement.
[a] *Median followed by distinct letters (capital letters in the horizontal compare composites within intermediary base; lowercase letters in the vertical compare intermediary base within composite) differ between them (*$p<0.05$*).*

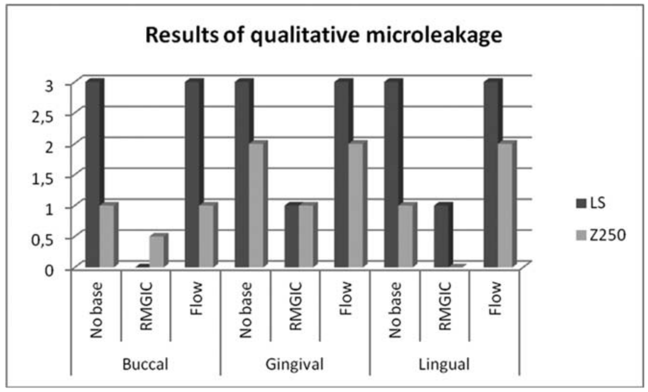

Figure 3. *Results of qualitative microleakage discriminated by walls.*

by walls. There was no statistical difference between the composite resins in the buccal and gingival walls. In the lingual wall, Filtek Z250 showed lower microleakage than did Filtek LS only for the RMGIC group. When comparing the intermediary base, RMGIC showed lower microleakage than did other groups for all walls in the group LS and for the lingual wall in group Z250.

DISCUSSION

This *in vitro* study qualitatively and quantitatively evaluated the microleakage of Class II restorations restored with methacrylate- and silorane-based composites using a low-viscosity resin or RMGIC as an intermediary base.

The first null hypothesis was partially rejected, since there was a difference found with the quantitative analysis when using different restorative materials. The silorane-based composite showed more microleakage than did the methacrylate-based composite. The second null hypothesis was rejected, since there was a difference in microleakage when different intermediary materials were used.

In the quantitative analysis, LS showed the highest values of microleakage, with a significant statistical difference from Z250. In the qualitative analysis, there were no differences between the restorative materials. These results indicate that both the methacrylate-based and silorane-based composites showed similar behavior only in the qualitative analysis of dye penetration. These findings indicate that low-shrinkage composites did not necessarily reduce the polymerization shrinkage stress at the tooth-restoration interface.[11] Microleakage is influenced by numerous factors related to the materials, technique, and cavity preparation, and the interaction between these factors dictates the exact manifestation of shrinkage for a given restoration.[3]

Several studies[8,9,12] have reported that silorane-based composites exhibit lower shrinkage rates and lower shrinkage volumes than do methacrylate-based composites because the polymerization reaction takes place by the opening and cleavage of a cationic ring structure.[12] However, a lower shrinkage rate does not necessarily indicate lower polymerization stress, especially if an incremental filling technique is used.[13]

Another factor to be considered is the possibility of the silorane-based composite being more susceptible to reduced curing of the bottom surface of the increment.[13] This composite exhibits a polymerization reaction with a slower onset because more energy density is required to form sufficient cations and initiate polymerization.[14,15] The irradiance that reaches the bottom surface of the cervical increment

Table 3: *Qualitative Microleakage Discriminated by Walls*[a]

Wall	Composite	
	LS Median	Z250 Median
Buccal		
No intermediary base	3.00 Aa	1.00 Aa
RMGIC	0.00 Ab	0.50 Aa
Flow	3.00 Aa	1.00 Aa
No intermediary base	3.00 Aa	2.00 Aa
Gingival		
RMGIC	1.00 Ab	1.00 Aa
Flow	3.00 Aa	2.00 Aa
No intermediary base	3.00 Aa	1.00 Aa
Lingual		
RMGIC	1.00 Ab	0.00 Bb
Flow	3.00 Aab	2.00 Aa

Abbreviation: RMGIC, resin-modified glass ionomer cement.
[a] *Median followed by distinct letters (capital letters in the horizontal compare composites within intermediary base; lowercase letters in the vertical compare intermediary base within composite) differ between them (*$p<0.05$*).*

is affected by the distance between the resin composite and tip of the light-curing unit and by the thickness of the resin composite.[16] Consequently, a low degree of conversion of silorane-based composite has been associated with a decreased mechanical strength of adhesives.[13]

The higher microleakage means of LS obtained using the quantitative analysis could also be explained by the adhesive systems. Restoration with Filtek Z250 was performed using the total etch technique and a single bottle adhesive, whereas Filtek LS required its own self-etch bonding system, which may explain the results. It has been well documented[17] that self-etch systems do not perform as well in enamel as total-etch systems. Additionally, the adhesive system of Filtek LS showed a bond mechanism similar to that of a one-step self-etching adhesive, since adhesion to the tooth surface is realized using the "ultra-mild" (pH>2.5) Primer LS, which superficially interacts with the smear layer.[13] One-step self-etching adhesives combine conditioning, priming, and application of the adhesive resin and do not require mixing. Consequently, they are considered to be more user friendly. However, they present major shortcomings, such as reduced immediate bond strength when compared to multi-step adhesives[18] and increased interfacial nano-leakage.[19]

The results for the qualitative technique showed no differences between the composites. The qualitative microleakage evaluation takes into account only a few points, whereas quantitative analysis evaluates the entire interface. It is possible to infer that this total evaluation could not detect differences between the restorative systems. Additionally, the quantitative method seems to be more suitable for detecting differences, since the entire interface is evaluated and considered in the final result of the sample. As a disadvantage, the quantitative technique is more time consuming and specific equipment is required. The results of this current study disagree with those of another study[20] that reported that different methods of microleakage evaluation do not differ in the final results.

On the other hand, the results of qualitative analysis showed no differences between the restorative systems. A possible explanation could be related to the higher failure of the LS adhesive, which was detected mainly by quantitative analysis.

In the quantitative and qualitative analyses, both composites showed statistically significant differences when considering the intermediary materials. The lowest results of marginal infiltration were obtained with RMGIC. The use of RMGICs as an intermediate layer for restorative materials has been suggested and largely applied. Previous studies[21-23] showed its benefits in lowering microleakage due to its thermal expansion, which is similar to that of dental structures; its bacteriostatic function; molecular bonding to dentin and enamel; and a low setting shrinkage.[23] The other intermediate material used in this current study was a flowable composite, which has been purported[24] to be able to diminish the stress during the polymerization shrinkage and to promote better sealing to dental structure as a result of its lower elastic modulus. However, the present study did not find this absorbing behavior, and the microleakage values found were similar to those of the control group. Flowable composite presents lower filler content and higher resin matrix than do traditional composites[22] and generally presents with a higher polymerization shrinkage volume, which has ranged from 3.6% a 6%, whereas traditional composites shrink around 1.9% and 2.3%. Increased volumetric shrinkage may indicate the potential for higher contraction stress at the restorative interface as well as the likelihood of bond failure.[22] These characteristics may explain the results obtained in this present study, which are in agreement with those of Oliveira and others.[25]

Finally, a qualitative analysis was performed that discriminated the microleakage by wall (Table 3). In general, the patterns of microleakage were similar on all of the walls, showing that stress distribution is concentrated in both the gingival and surrounding walls, independent of the composite resin used. The results of the present study corroborate with the study by Oliveira and others,[25] which demonstrated a high stress concentration in the gingival wall, surround- gingival angle, and the surrounding wall close to the angle, in a photoelastic model study. The association between the high concentration shrinkage stress and the inadequate polymerization at the bottom surface of the composite resin is a crucial factor for increasing the microleakage in this area.

CONCLUSION

Based on the experimental results from this study:

1. The silorane-based composite was not able to reduce marginal infiltration.
2. Regardless of restorative material, a RMGIC intermediary base showed lower results of marginal infiltration.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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REFERENCES

1. Ferracane JL (2008) Bunocore Lecture: Placing dental composites: A stressful experience *Operative Dentistry* **33(3)** 247-257.
2. Navarra CO, Cadenaro M, Armstrong SR, Jessop J, Antoniolli F, Valter S, Di Lenarda R, & Breschi L (2009) Degree of conversion of Filtek Silorane Adhesive System and Clearfil SE Bond within the hybrid and adhesive layer: An in situ Raman analysis *Dental Materials* **25(9)** 1178-1185.
3. Peutzfeldt A, & Asmussen E (2004) Determinants of in vitro gap formation of resin composites *Journal of Dentistry* **32(2)** 109-115.
4. Kidd EAM (1976) Microleakage: A review *Journal of Dentistry* **4(5)** 199-206.
5. Bagis YH, Baltacioglu IH, & Kahyaogullari S (2009) Comparing microleakage and the layering methods of silorane-based resin composite in wide Class II MOD cavities *Operative Dentistry* **34(5)** 578-585.
6. Peris AR, Duarte S, & Andrade MF (2003) Evaluation of marginal microleakage in Class II cavities: Effect of microhybrid, flowable, and compactable resins *Quintessence International* **34(2)** 93-98.
7. Kwon OH, Kim DH, & Park SH (2010) The influence of elastic modulus of base material on the marginal adaptation of direct composite restoration *Operative Dentistry* **35(4)** 441-447.
8. Weinmann W, Thalacker C, & Guggenberger R (2005) Siloranes in dental composites *Dental Materials* **21(1)** 68-74.
9. Lien W, & Vandewalle KS (2010) Physical properties of a new silorane-based restorative system *Dental Materials* **26(4)** 337-344.
10. Ernst CP, Meyer GR, Klocker K, & Willershausen B (2004) Determination of polymerization shrinkage stress by means of a photoelastic investigation *Dental Materials* **20(4)** 313-321.
11. Tantbirojn D, Pfeifer CS, Braga RR, & Versluis A (2011) Do low-shrink composites reduce polymerization shrinkage effects? *Journal of Dental Research* **90(5)** 596-601.
12. Naoum SJ, Ellakwa A, Morgan L, White K, Martin FE, & Lee IB (2012) Polymerization profile analysis of resin composite dental restorative materials in real time *Journal of Dentistry* **40(1)** 64-70.
13. Van Ende A, De Munk J, Mine A, Lambrechts P, & Van Meerbeek B (2010) Does a low-shrinking composite induce less stress at the adhesive interface? *Dental Materials* **26(3)** 215-222.
14. Palin WN, Flaming GJ, Nathwani H, Burke FJ, & Randall RC (2005) In vitro cuspal deflection and microleakage of maxillary premolars restored with novel low-shrink dental composites *Dental Materials* **21(4)** 324-335.
15. Bouillaguet S, Gamba J, Forchelet J, Krejci I, & Wataha JC (2006) Dynamics of composite polymerization mediates the development of cuspal strain *Dental Materials* **22(10)** 896-902.
16. Aguiar FHB, Lazzari CR, Lima DANL, Ambrosano GMB, & Lovadino JR (2005) Effect of light curing tip distance and resin shade on microhardness of a hybrid resin composite *Brazilian Oral Research* **19(4)** 302-306.
17. Perdigão J, & Geraldeli S (2003) Bonding characteristics of self-etching adhesives to intact versus prepared enamel *Journal of Esthetic and Restorative Dentistry* **15(1)** 32-41.
18. Van Landuyt KL, Mine A, De Munk J, Jaecques S, Peumans M, Lambrechts P, & Van Meerbeek B (2009) Are one-step adhesives easier to use and better performing? Multifactorial assessment of contemporary one-step self-etching adhesives *Journal of Adhesive Dentistry* **11(3)** 175-190.
19. Tay FR, King NM, Chan KM, & Pashley DH (2002) How can nanoleakage occur in self-etching adhesive systems that demineralize and infiltrate simultaneously? *Journal of Adhesive Dentistry* **4(4)** 255-269.
20. Tredwin CJ, Stokes A, & Moles DR (2005) Influence of flowable liner and margin location on microleakage of conventional and packable Class II resin composites *Operative Dentistry* **30(1)** 32-38.
21. Hagge MS, Mason JF, & Simon JF (2001) Effect of four intermediate layer treatments on microleakage of Class II composite restorations *General Dentistry* **49(5)** 489-495, quiz 496-497.
22. Chuang SF, Jin YT, Lin TS, Canh CH, & Garcia-Godoy F (2003) Effects of lining material on microleakage and internal voids of Class II resin-based composite restorations *American Journal of Dentistry* **16(2)** 84-90.
23. Kasraei S, Azarsina M, & Majidi S (2011) In vitro comparison of microleakage of posterior resin composites with and without liner using two-step etch-and-rinse and self-etch dentin adhesive systems *Operative Dentistry* **36(2)** 213-221.
24. Unterbrink GL, & Liebenberg WH (1999) Flowable resin composites as "filled adhesives": Literature review and clinical recommendations *Quintessence International* **30(4)** 249-257.
25. Oliveira LCA, Duarte S Jr, Araujo CA, & Abrahão A (2010) Effect of low-elastic modulus liner and base as stress-absorbing layer in composite resin restorations *Dental Materials* **26(3)** e159-e169.