Received: 10th April 2015 Accepted: 09th July 2015 Conflicts of Interest: None

Source of Support: Nil

Original Research

Evaluation of Microleakage of Silorane and Methacrylate Based Composite Materials in Class I Restorations by Using Two Different Bonding Techniques

Mohsen S Alshetili[1], Sultan S Aldeyab[2]

Contributors:
[1]Specialist, Department of Conservative Dentistry, East Riyadh Specialized Dental Centre, Ministry of Health, Riyadh, Saudi Arabia; [2]Consultant, Department of Restorative Dentistry, King Abdulaziz Medical City, Riyadh, Saudi Arabia

Correspondence:
Alshetili MS. Department of Conservative Dentistry, East Riyadh Specialized Dental Centre, Ministry of Health, Riyadh, Saudi Arabia. Phone: +966-542222421, Fax: +966-14227914, Email: MOHSIN11113@gmail.com

How to cite the article:
Alshetili MS, Aldeyab SS. Evaluation of microleakage of silorane and methacrylate based composite materials in Class I restorations by using two different bonding techniques. J Int Oral Health 2015; 7(Suppl 2):6-9.

Abstract:
Background: To evaluate the microleakage of silorane-based composite material (Filtek P90) with that of two homologous methacrylate-based composites materials (Filtek Z250 and Filtek Z250 XT), by using two different bonding techniques.

Materials and Methods: Sixty extracted human maxillary first premolars prepared for standardized Class I cavities (4 mm × 2 mm × 2 mm) were randomly divided into three groups. Group A ($n = 20$) was filled with Filtek Z250 (Methacrylate) using single bond universal total etching technique, Group B ($n = 20$) was filled with Filtek Z250 XT (Methacrylate) using single bond universal self-etching technique and Group C ($n = 20$) restored with Filtek P90 (Silorane) with dedicated two-step self-etching prime and bond adhesive system (P90 system adhesive). Teeth were subjected to thermocycling regime (500×, 5-55°C), and dye penetration by immersing in 2% methylene blue for 24 h. Tooth sectioning was performed, and extent of the dye penetration was scored based on dye penetration scale to evaluate the microleakage. Statistical analysis included descriptive statistics and inferential statistics of Kruskal–Wallis test to compare the mean ranks between groups.

Results: There was no significant difference observed for microleakage among the three composite materials tested in the present study. However, the cavities restored with silorane (Filtek P90) based composite displayed higher microleakage than the Filtek Z250, Z250 XT.

Conclusion: All the restorative systems tested in this study exhibited microleakage, but the silorane technology showed more microleakage when compared to the methacrylate-based composite systems.

Key Words: Bonding, composite, microleakage, nano-hybrid, self-etch, silorane, total etch

Introduction

Esthetic restorative materials have been widely used in dentistry in both anterior and posterior restorations. These are presented with different physical characteristics, colors, and shades. Currently, four types of direct esthetic restorations are commonly used in dentistry which includes - resin composites, poly-acid modified resin composites (copolymer), glass-ionomers and resin-modified glass-ionomers. Resin composites were introduced in the early 1970s and are widely used as direct esthetic restorations.[1] However, composite restorations have several significant disadvantages despite their continuous improvements.[2] Despite the fact that composites are currently the most preferred material for restorations, the polymerization shrinkage of 2.6-7.1% prompting microleakage is one of the most often observed issues.[3-14]

Microleakage is one of major drawbacks of composites which lead to the development of recurrent caries, post-operative sensitivity, enamel fracture, marginal staining, and eventual failure of restorations.[4] Studies have reported several ways to decrease this problem such as slowing down the composite polymerization rate, utilizing an incremental build-up technique or placement of low modulus in-between layer, and reducing the C factor (the ratio of bonded to non-bonded restoration surfaces).[5]

Silorane-based dental resin composite materials introduced to clinical dentistry with an intention to reduce the polymerization shrinkage. Its matrix consists of siloxanes and oxiranes, which differ from the conventional methacrylate (Bis-GMA) composite matrix. Manufactures claimed that the silorane-based composites produce low-polymerization shrinkage of <1% volume by using Archimedes' method. Silorane-based composites polymerize by open ring polymerization reaction minimizing polymerization shrinkage and polymerization stress. Thus, it provided a high-performance bond to the tooth with significantly lower shrinkage than other methacrylate composites.[6,7] Moreover, oxirane and siloxane were hydrophobic in nature making silorane based composites chemically stable in aqueous solution with less water sorption. Additionally, silorane-based dental resin composites showed less microleakage and cusp deflection compared to other Bis-GMA composite materials.[8-11]

By utilizing Bis-GMA based technology, nontraditional "nano-hybrids" composite materials have been developed. These contained sub-micrometer particles (Nano fillers) to further improve the physical and optical properties of the resins. Nanohybrid composites with Bis-GMA base has been recommended for both anterior and posterior restorations. Further, it has been improved to overcome composite drawbacks of recurrent caries, post-operative sensitivity, enamel fracture, marginal staining, microleakage and eventual failure of restorations.

To the best of our knowledge, there is a lack of reported studies on the comparative evaluation of microleakage of methacrylate based nanohybrid and microhybrid composite materials with that of silorane based microhybrid composite materials. Hence, the present study is aimed to evaluate the microleakage of silorane based (Filtek P90, using two-step self-etching prime and bond adhesive system) composite material with that of methacrylate based (Filtek Z250 using single bond universal total etching technique, and Filtek Z250 XT using single bond universal self-etching technique) composite materials in Class I restorations by using stereomicroscope.

Materials and Methods

Sixty extracted intact upper premolar teeth were collected, and removal of calculus and debris was carried out by hand scaling. Teeth were kept in 5% sodium chloride solution at 37°C for the duration of 1-month. Teeth were prepared approximately 4 mm in length mesio-distally, 2 mm bucco-palatally in width and 3 mm in depth to receive standardized Class I restoration by using prefabricated polyvinylsiloxane mold of 2 mm × 4 mm. The corresponding depth of the cavity was obtained with a diamond bur marked 3 mm from the tip of the bur. Marking on the bur was carried out by using carborundom disk (B&D Technologies CO, Nanyi Street, Qiaonan, PanYu, Guangzhou, 511400 China). All the Class I cavities was prepared by using high-speed hand piece (NSK, Avtec Dental, Mount Pleasant, SC, U.S.A.), under constant water irrigation. New bur was supplanted after preparing five teeth. 90° cavosurface margins were prepared, and the dimensions of the cavities were checked with a Boley gauge. Specimen measurement tolerance of 0 ± 0.3 mm was accepted in the study. Later teeth were randomly divided into three (n = 20) groups to receive restorative materials.

Group A

Filtek Z250 resin composite shade A2 (3M ESPE, St. Paul, MN, USA) with single universal bond (3M ESPE, St. Paul, MN, USA) was used as per the manufacturer's instructions. A Phosphoric acid etching gel 35% (Scotchbond Universal Etchant, 3M ESPE, St. Paul, MN, USA) was applied to the prepared tooth structure for 15 s. Rinsed with water and dried carefully without incorporating oil or water. Precautions were taken to avoid over drying of the cavity. Then, the bonding agent applied with a scrubbing motion for 20 s and exposed to the gentle stream of air for 5 s, followed by light curing for 10 s. Filtek Z250 was placed in a cavity in two increments with each increment of 2 mm size as per the manufacturer's instructions and light cured for 40 s.

Group B

Filtek Z250 XT resin composite shade A2 (3M ESPE, St. Paul, MN, USA) with single bond universal self-etch (3M ESPE, St. Paul, MN, USA) was used according to the manufacturer's instructions. The bonding agent was applied with a scrubbing motion for 20 s and the gentle air stream was passed for 5 s before it could be light-cured for 10 s. Composite Filtek Z250 XT was placed by using the same protocol as described in Group A.

Group C

Low shrinkage resin composite Filtek P90 shade A2 (3M ESPE, St. Paul, MN, USA) with LS system adhesive primer and bond (3M ESPE, St. Paul, MN, USA) was used in the present study. All teeth were cleaned with water spray and blot dried. The P90 primer was applied by using a micro brush for 15 s, mildly air-dried and finally light-cured for 10 s. The P90 bond was applied, and a gentle stream of air was passed and light-cured for 10 s. P90 was placed by using the same protocol as described in Group A according to the manufacturer's instructions and light cured for 40 s.

All the specimens were polished with a series of coarse, medium, fine and superfine polishing discs (Sof-Lex; 3M/ESPE, St. Paul, MN, USA) with an electric handpiece (K10; Kavo, Leutkirch, Germany) at 15,000 rpm for 15 s.

All composite increments were light-cured using Elipar™ S10 LED curing unit (3M ESPE, Seefeld, Germany) at a power density of 1000 mW/cm^2 for 40 s in a soft start mode, whereas adhesive systems were light-cured using the same light-curing unit with power density for 10 s. The integrated radiometer was utilized to continuous monitoring of the light intensity. Specimens were kept in distilled water for 24 h at 37°C. Teeth were then subjected to thermocycling, according to the International Organization for Standardization standard 11405 for 500 cycles at 5C-55C with a 30-s dwell time.

Before the evaluation of the microleakage, the root apices of the teeth were completely sealed with sticky wax and two coats of nail varnish was applied over the crown root surfaces except for 1 mm around the restoration margins. Teeth were then drenched in 2% methylene blue dye (pH = 7) (Merck Specialties Private Ltd, Mumbai, India) at 37°C for 24 h,[13] washed and dried. Later on, teeth were embedded in the acrylic resin block sectioned longitudinally in bucco-lingual direction with a diamond saw mounted on a cutting machine (Isomet 1000; Buehler 41 Waukegan Road Lake Bluff, Illinois USA). Deepest dye penetrated section was selected to represent the tooth. Stereomicroscopic (Motic Microscopes, China) examination was carried out to determine the extent of dye penetration at ×40 magnification based on five-point scale.

0 = No dye penetration;
1 = Dye penetration limited to outer half of the axial wall;
2 = Dye penetration limited to inner half of the axial wall;
3 = Dye penetration reach the pulpal wall;
4 = Dye penetration beyond the pulpal wall.

Descriptive statistics of mean and mean ranks were calculated. Inferential statistics of Kruskal–Wallis test and the Mann–Whitney test were executed at a 95% significance level to evaluate any significant differences among the composite materials. All the Statistical analysis was performed using the SPSS 11.0 program (SPSS Inc., Chicago, IL, USA). The level of significance was set at $P < 0.05$.

Results

Descriptive statistics of mean, standard deviations, minimum and maximum scores for dye penetration test as shown in Table 1. It is evident that silorane-based composite material Filtek P90 showed a highest mean score of 2.45 ± 0.89, as compared to methacrylate based composite materials Filtek Z250 and Filtek Z250 XT. Number of teeth showing dye penetration reaching the pulpal wall of the cavity was highest (n = 14) with Filtek P90 (silorane) composite material as compared to the other two composite materials (Graph 1).

Mean ranks of dye penetration scores as in Table 2. A highest mean rank of 33.65was observed with Filtek P90 (silorane), followed by 30.55 and 27.30 Filtek Z250 XT (methacrylate) and Filtek Z250 (methacrylate), respectively. Further comparison of mean ranks among different composite materials by Kruskal–Wallis test revealed no significant differences ($P > 0.05$) (Table 2).

Discussion

Microleakage of composite restorations occurs because of stresses encountered along the tooth/restoration margin from polymerization shrinkage, temperature variation in the oral environment, and mechanical fatigue through repetitive masticatory loading.[15]

The most likely cause for this phenomenon is polymerization contraction, which is toward the "stronger" enamel composite joint and the light source.[4-10] Various methods to detect microleakage have been suggested including dye leakage method, the use of color producing microorganisms, radioactive isotopes, the air pressure method, neutron activation analysis, electrochemical studies, scanning electron microscopy, thermal and mechanical cycling, and chemical tracers.[16] A newer silorane-based composite resin system was designed to overcome polymerization contraction issue.[6,17] The present study investigated the microleakage of a new low-shrinkage resin composite and clinically successful methacrylate resin composites in Class I restorations. These Class I cavities was chosen due to the high C-factor that leads to greater polymerization stresses,[18] as a result of confined contraction by number of bonded surfaces.

All the three composite materials utilized in this study exhibited some degree of leakage. We did not observe any significant differences in microleakage among the three composite resin systems. This could be due to the use of high intensity light in a continuous mode, self-etch hydrophilic adhesive systems, the increased C-factor of Class I cavity and the relatively excess concentration of methylene blue dye used in this study.

The results of this study showed that the novel low-shrink composite restorative material Filtek P90 showed microleakage score very similar to Z250 with total etch single universal bond and Z250 XT with self-etch systems after thermocycling.

Assumption that microleakage of the cavities restored with the Filtek P90 (silorane) compared to the other resin-based composite materials was due to the innate ring-opening polymerization reaction of the silorane monomers, which make-up the volumetric reduction as the molecules approximate each other. However, radical polymerization of the other resin based composites is obvious with a decrease in polymerization shrinkage stresses at the tooth/restoration border. Therefore, methacrylate based composite resins better withstand thermocycling fatigue at the tooth/restoration interface.

Our study is in agreement with the study reported by Ernst, who presented no differences in microleakage of teeth restored with silorane and methacrylate composite (Tetric Ceram) with adhesive (Clearfil SE Bond) system.[13] This finding was due to the fact that author used an all-in-one (7[th] generation)

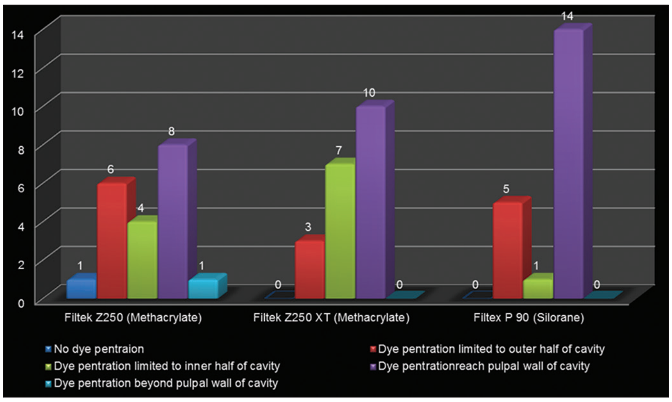
Table 1: Dye penetration test.

Composite materials	Mean	SD	Minimum	Maximum
Filtek Z250 (methacrylate)	2.10	1.07	0.00	4.00
Filtek Z250 XT (methacrylate)	2.35	0.75	1.00	3.00
Filtek P90 (silorane)	2.45	0.89	1.00	3.00

SD: Standard deviation

Table 2: Mean rank as in Kruskal-Wallis test.

Composite material	*N*	Mean rank	Chi-square	df	*P* value
Filtek Z250 (methacrylate)	20	27.30	1.597	2	0.450
Filtek Z250 XT (methacrylate)	20	30.55			
Filtek P90 (silorane)	20	33.65			
Total	60				



Graph 1: Distribution of microleakage among different composites (n).

experimental bond of silorane before produced by the company. Whereas in the present study new bond produced with silorane composite system consisting of two-step and two components (6th generation) was utilized. However, we disagree with study results of Palin *et al*., who have reported that the microleakage of silorane based composite material was lesser than that of methacrylate based composite after occlusal loading forces.[19-21]

Conclusion

Within the limitation of this study, we conclude that all the restorative systems tested in this study exhibited microleakage. However, silorane based technology (Filtek P90) showed higher microleakage scores compared with the clinically successful methacrylate-based composite materials (Filtek Z250 and Filtek Z250 XT).

Acknowledgement

We would like to thank Professor Mohammad Al-Omari, Chairman, Restorative Department, RCsDP and King Abdullah International Medical Research Center for providing needed help and assistance during the study.

References

1. Craig RG, Powers JM, Wataha JC. Dental Materials Properties and Manipulation, 10th ed. St, Louis: Mosby; 2012.
2. Hickel R, Heidemann D, Staehle HJ, Minnig P, Wilson NH, German Scientific Association for Operative Dentistry, European Federation of Conservative Dentistry. Direct composite restorations: Extended use in anterior and posterior situations. Clin Oral Investig 2004;8(2):43-4.
3. Yazici AR, Celik C, Ozgünaltay G. Microleakage of different resin composite types. Quintessence Int 2004;35(10):790-4.
4. Idriss S, Abduljabbar T, Habib C, Omar R. Factors associated with microleakage in Class II resin composite restorations. Oper Dent 2007;32(1):60-6.
5. Krejci I, Sparr D, Lutz F. A three-sited light curing technique for conventional Class II composite resin restorations. Quintessence Int 1987;18(2):125-31.
6. Weinmann W, Thalacker C, Guggenberger R. Siloranes in dental composites. Dent Mater 2005;21(1):68-74.
7. El-Mowafy O, El-Badrawy W, Eltanty A, Abbasi K, Habib N. Gingival microleakage of Class II resin composite restorations with fiber inserts. Oper Dent 2007;32(3):298-305.
8. Eick JD, Smith RE, Pinzino CS, Kostoryz EL. Stability of silorane dental monomers in aqueous systems. J Dent 2006;34(6):405-10.
9. Palin WM, Fleming GJ, Nathwani H, Burke FJ, Randall RC. *In vitro* cuspal deflection and microleakage of maxillary premolars restored with novel low-shrink dental composites. Dent Mater 2005;21:95-102.
10. Al-Boni R, Raja OM. Microleakage evaluation of silorane based composite versus methacrylate based composite. J Conserv Dent 2010;13(3):152-5.
11. Basavanna R, Garg A, Kapur R. Evaluation of gingival microleakage of class II resin composite restorations with fiber inserts: An *in vitro* study. J Conserv Dent 2012;15(2):166-9.
12. Agrawal VS, Parekh VV, Shah NC. Comparative evaluation of microleakage of silorane-based composite and nanohybrid composite with or without polyethylene fiber inserts in class II restorations: an *in vitro* study. Oper Dent 2012;37(5):E1-7.
13. Ernst CP, Galler P, Willershausen B, Haller B. Marginal integrity of class V restorations: SEM versus dye penetration. Dent Mater 2008;24(3):319-27.
14. Yoshikawa T, Sano H, Burrow MF, Tagami J, Pashley DH. Effects of dentin depth and cavity configuration on bond strength. J Dent Res 1999;78(4):898-905.
15. Kubo S, Yokota H, Sata Y, Hayashi Y. The effect of flexural load cycling on the microleakage of cervical resin composites. Oper Dent 2001;26(5):451-9.
16. Taylor MJ, Lynch E. Microleakage. J Dent 1992;20(1):3-10.
17. Guggenberger R, Weinmann W. Exploring beyond methacrylates. Am J Dent 2000;13:82D-4.
18. 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):1636-9.
19. Palin WM, Fleming GJ, Nathwani H, Burke FJ, Randall RC. *In vitro* cuspal deflection and microleakage of maxillary premolars restored with novel low-shrink dental composites. Dent Mater 2005;21(4):324-35.
20. Yamazaki PC, Bedran-Russo AK, Pereira PN, Wsift EJ Jr. Microleakage evaluation of a new low-shrinkage composite restorative material. Oper Dent 2006;31(6):670-6.
21. Bagis YH, Baltacioglu IH, Kahyaogullari S. Comparing microleakage and the layering methods of silorane-based resin composite in wide Class II MOD cavities. Oper Dent 2009;34(5):578-85.