ORIGINAL ARTICLE

The effect of pre-heating silorane and methacrylate-based composites on microleakage of Class V restorations

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ABSTRACT

Objective: This study compared the effects of 4 different temperatures (4°C, 25°C, 37°C, 60°C) on the microleakage of silorane and methacrylate-based composites in Class V cavities. **Materials and Methods:** Standard Class V cavities were prepared at the buccal and lingual surfaces of human molars. The specimens were randomly divided into 2 groups according to the composite resin used (Group I: Filtek Silorane Adhesive System and Filtek Silorane composite; Group II: Clearfil SE Bond and Aelite LS Posterior composite) and into 4 subgroups according to temperature treatment (Group A: Refrigeration at 4°C; Group B (control): Storage at room temperature (25°C); Group C: Heated to 37°C and Group D: Heated to 60°C using Calset). Specimens were dyed with 0.5% basic fuchsin, sectioned, and evaluated at 25x magnification. Statistical analysis was performed using Mann-Whitney U and Kruskal-Wallis tests at $P<0.05$. **Results:** Filtek Silorane and Aelite LS Posterior showed similar microleakage values ($P>0.05$). Differences in temperature did not significantly affect microleakage values for Filtek Silorane ($P>0.05$); however, microleakage values of Aelite LS Posterior composite varied according to temperature treatment, with heating resulted in significantly less microleakage than cooling (between Groups IID and IIA and Groups IIC and IIA) ($P<0.05$). **Conclusion:** Pre-heating was shown to reduce microleakage values of Aelite LS Posterior composite, but did not significantly alter the microleakage values of Filtek Silorane composite.

Key words
Microleakage, pre-heating, silorane-based composite

INTRODUCTION

The clinical success of composite restorations is closely related to material characteristics, including polymerization shrinkage and degree of conversion.[1] Viscosity, polishability, packability, and adhesion also play critical roles.[2] Highly viscous materials such as composites with high-density filler content and hybrid resin composites may not adapt fully to cavity preparations,[3,4] leaving voids between the resin composite restoration and the underlying tooth surface that can lead to poor marginal integrity.[5]

The recent literature suggests that increasing the flowability of composite resins by raising the temperature of the composite before placement can have beneficial results.[6] The pre-heating process enhances composite flow, which in turn improves the adaptation of the material to the walls of the cavity preparation and reduces microleakage, thus diminishing extrinsic staining of the restoration.[7-9] A new device has been marketed to heat traditional, higher-fill composite resins prior to extrusion.[10,11] The Calset Compule Warmer (AdDent Inc®, Danbury, CT, USA) raises the temperature of unpolymerized composite resin paste to 37°C, 54°C, or 60°C prior to placement in the cavity preparation.

The viscosity of unpolymerized composite resin paste decreases with increasing temperature.[10] Enhanced flow can be an advantage in terms of composite placement, especially in the case of stiffer materials, as it can provide better adaptation to the cavity walls.[6,8] In addition, the higher temperature of the resin composite may increase the degree of conversion at the top and bottom 2 mm,[8] and composites with greater conversion are assumed to be highly cross-linked and possess better mechanical properties.[12] At the same time, pre-heating has been shown to have detrimental effects on restoration margins due to greater polymerization shrinkage.[1] Although modern composites exhibit both physical resistance and

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pleasing esthetics, inevitable polymerization shrinkage and related polymerization stress are major problems.[13,14]

Most resin-based composites used by clinicians today are based on methacrylate chemistry. Studies have shown polymerization shrinkage of methacrylate-based hybrid composites to range from 1.9% to 3.5%.[15,16] Researchers have attempted to reduce shrinkage rates by changing the chemical characteristics of the resin. A new resin chemistry synthesized from oxirane and siloxane molecules-known as 'silorane' has been suggested as an alternative to methacrylate as a dental composite resin matrix component because of its hydrophobicity and lower polymerization shrinkage.[17]

Microleakage is a phenomenon, in which oral micro-organisms, fluids, and chemical substances are diffused through the interface between tooth structure and restorative material. Fluids may progress through the dentin into the pulp, resulting in post-operative sensitivity, recurrent caries, pulpal inflammation, and restoration failure.[18] The rapid development of dental materials and the time needed for *in vivo* and *in vitro* studies has meant that the effects of pre-heating of resin composites on marginal microleakage has not received sufficient attention. Therefore, this study aimed to investigate the effects of temperature (4°C, 25°C, 37°C, 60°C) on the microleakage of hybrid and silorane-based composite resins used in Class V cavity restorations. The null hypothesis of the study was that microleakage values would not be affected by composite type (silorane *vs*. methacrylate-based nanofilled hybrid) or temperature treatment.

MATERIALS AND METHODS

One hundred-twelve standard Class V cavities were prepared on the buccal and lingual surfaces of 56 extracted human molars 2 mm above the cemento-enamel junction using a standardized template to create cavities 3 mm wide and 2 mm high, with a depth of 1.5 mm, as measured by a periodontal probe. Following preparation, the specimens were randomly divided into 2 groups (*n*=56) according to adhesive systems and composite resins used, as follows:

Group I: Filtek Silorane Adhesive System (3M ESPE®, St.Paul, MN, USA) and Filtek Silorane composite (3M ESPE, St.Paul, MN, USA) were applied according to the manufacturer's instructions.

Group II: Clearfil SE Bond (Kuraray®, Osaka, Japan) and A2 shade Aelite LS Posterior composite (Bisco, Schaumburg, IL, USA) were applied according to the manufacturers' instructions [Table 1].

Groups I and II were subdivided into 4 groups (*n*=14) each according to temperature treatment of composites, as follows:

Subgroup A: Resin composites were refrigerated for 24 h until they reached a temperature of 4°C.
Subgroup B: Resin composites were stored at controlled room-temperature for 24 h until they reached a temperature of 25°C.
Subgroup C: Resin composites were pre-heated to 37°C.
Subgroup D: Resin composites were pre-heated to 60°C.

Composite resins in the pre-heated groups were placed in a unit (Calset, AdDent Inc®, Danbury, CT, USA). This unit was used with the standard tray. For restorations utilizing the pre-heated composite, the composite tube was inserted into the hole and composite resins were respectively heated to a temperature of 37°C or 60°C, and then placed immediately into the tooth cavity after removing the resin from the Calset unit. A previous study has shown that there is an approximate 25°C decrease in temperature in the 2 min after removing the composite

Table 1: Materials used in this study

Materials	Composition	Application mode
Filtek silorane 3M ESPE®, St. Paul, MN, USA Batch# N175794	Bis-3,4-Epoxycyclohexylethylphenylmethylsilane, 3,4-Epoxycyclohexylcyclopolymethylsiloxane, Silanized, Quartz, Yttrium fluoride	Applied resin composites, light-cured for 20s
Filtek silorane primer 3M ESPE®, St. Paul, MN, USA Batch# N186806	Phosphorylated methacrylates, Vitrebond copolymer, Bis-GMA, HEMA, Water, Ethanol, Silorane-treated silica filler	Self-etch primer applied for 15 s, air-blowed, polymerized for 10 s
Filtek silorane adhesive 3M ESPE®, St. Paul, MN, USA Batch# N180901	Hydrophobic dimethacrylate, Phosphorylated methacrylates, TEGDMA, Silorane-treated silica filler	Applied for 10 s, air-blowed, polymerized for 10 s
Aelite LS posterior Bisco®, Schaumburg, IL, USA Batch# 110000387	Ethoxylated Bis-GMA., Glass Filler. Amorphous Silica	Applied resin composites, light-cured for 20s
Clearfil SE Bond Kuraray®, Osaka, Japan Primer Batch# 041874	Primer: MDP, HEMA, hydrophilic dimethacrylate, dl-camphorquinone, N, N-diethanol-p-toluidine, water	Primer applied with a brush for 20 s, gently air dried,
Clearfil Se Bond Kuraray, Osaka, Japan Bond Batch#041874	Bond: MDP, bis-GMA, HEMA, hydrophobic dimethacrylate, dl- camphorquinone, N,N-diethanol-p-t oluidine, silanated colloidal silica	Bonding agent applied gently air-dried, light cured for 10 seconds

resin from the heating unit.[19] Therefore, it is important to place the composite as quickly as possible. Temperature-treated resin composites were placed in bulk because of cavity depth was less than 2 mm and light-cured for 20s using a blue light emitting diode device (Elipar Free Light III, 3M ESPE®, St.Paul, MN, USA). Light curing unit was controlled throughout the experiment for its intensity. The specimen preparation and testing were performed at controlled room temperature (25°C).

Twenty-four hours after filling, excess material was removed using a polishing bur (SE6-20, SS White Burs®, Inc., USA), and restorations were polished using a disc system (Sof-lex Pop-on, 3M®, St. Paul, MN, USA). All specimens were stored in a moisture medium at 37°C for 24 h.

Teeth were removed from storage, coated with nail varnish up to 1 mm from the cavity surface margins, immersed in 0.5% basic fuchsin dye for 24 h, and sectioned longitudinally through the center of the restoration using a low-speed diamond saw under water spray.[5,9]

Sectioned restorations were examined under a stereomicroscope (Olympus SZ61, Olympus Optical Co®, Tokyo, Japan) at 25x magnification. Dye penetration along the occlusal and cervical margins of the tooth-restoration interface was evaluated by 2 independent observers and recorded based on the graded scoring system[20] given in below:

0= No dye penetration;
1= Dye penetration involving the half of occlusal/gingival wall;
2= Dye penetration involving more than the half of occlusal/gingival wall;
3= Dye penetration involving axial wall;

Statistical analysis was performed using Mann-Whitney U and Kruskal-Wallis tests at $P<0.05$. Multiple comparisons were made using the Tukey test.

RESULTS

The mean microleakage scores of all groups are listed in Tables 2 and 3. Although microleakage scores of the Filtek Silorane groups were lower than those of the Aelite LS Posterior, the differences between them were not statistically significant ($P=0.063$). For the Filtek Silorane groups, these differences were not statistically significant ($P=0.084$); however, for the Aelite LS Posterior groups, heating to 37°C and 60°C resulted in significantly less microleakage than cooling to 4°C ($P<0.001$ and $P<0.003$, respectively).

With the exception of the Aelite LS Posterior subgroup at 25°C ($P=0.043$), no significant differences was observed at either the enamel or dentin in the microleakage scores.

Table 2: Enamel microleakage scores

Composites	Temperature treatments	Leakage scores			
		0	1	2	3
(Group I)	Group A (4°C)	8	6	0	0
Filtek silorane	Group B (25°C)	11	3	0	0
	Group C (37°C)	11	2	1	0
	Group D (60°C)	13	1	0	0
(Group II)	Group A (4°C)	2	11	1	0
Aelite LS	Group B (25°C)	10	4	0	0
posterior	Group C (37°C)	12	2	0	0
	Group D (60°C)	11	3	0	0

Table 3: Dentin microleakage scores

Composites	Temperature treatments	Leakage scores			
		0	1	2	3
(Group I)	Group A (4°C)	5	9	0	0
Filtek	Group B (25°C)	7	7	0	0
silorane	Group C (37°C)	7	5	2	0
	Group D (60°C)	11	3	0	0
(Group II)	Group A (4°C)	5	3	0	6
Aelite LS	Group B (25°C)	6	2	2	4
posterior	Group C (37°C)	9	2	1	2
	Group D (60°C)	9	1	1	3

DISCUSSION

The null hypothesis in the present study was partially rejected. Pre-heating of resin composites reduced microleakage; however, microleakage was not affected by the chemical composition of the resin composites.

The purpose of microleakage testing is to obtain information about the sealing ability of a restoration-adhesive complex. Because human teeth and clinical protocols are used, the results of *in vitro* microleakage studies are close to clinical reality. Failure of the restoration to achieve an adequate seal may contribute to marginal staining, adverse pulpal response, post-operative sensitivity, and recurrent caries.[21]

Dye penetration testing is one of the main methods in evaluating microleakage. In this method, the sample is subjected to a dye marker such as methylene blue, basic fuchsin silver nitrate, and rarely India ink. But, there is no evidence supporting any correlation between clinical testing and *in vitro* dye penetration testing. In the present study, 0.5% basic fuchsin dye was used in assessing the microleakage *in vitro*.[22] Furthermore, in the present study, the teeth was sectioned longitudinally through the center of the restoration; therefore, the microleakage scores could be evaluated as two-dimensional. This may have some limitations to obtain real microleakage values, because it could not be examined as 3-dimensional. In the present study, this method was preferred, because it is easier and cheaper than other techniques.

Resin composites set mainly by photopolymerization, a process that is temperature-dependent, with the rate of conversion increasing with increases in temperature. While a higher degree of conversion may improve the physical properties of the composite by leaving fewer residual monomers, it may also increase shrinkage.[6] Some researchers recommend the use of flowable composite as a cavity liner to minimize shrinkage stress;[21] however, due to their lower filler loading, flowable composites have inferior mechanical properties when compared to conventional composite resins.[23] Pre-heating may increase the flowability of resin composites. A study by Deb and others[6] showed that all composites tested had a greater flow at higher temperatures. Increases in temperature decrease resin composite viscosity and enhance radical mobility, resulting in additional polymerization.[8] This can make it easier for the clinician in terms of placement and improve the adaptation of the material within the cavity walls. Furthermore, the free volume of the resin composite increases with increases in temperature, leading to greater mobility of trapped radicals and further conversion.[24] Previous studies have also found a higher degree of conversion in top and bottom surfaces when resin composite was pre-heated to 54^{o}C and 60^{o}C.[3,8]

In the present study, pre-heating reduced the microleakage of Aelite LS Posterior composite, but had no effect on the microleakage of Filtek Silorane. Froes-Salgado *et al.*[25] found pre-heated composite showed better marginal adaptation than room-temperature composite. Another *in vitro* study found microleakage of pre-heated resin composite to be statistically lower than that of non-heated composite as well as non-heated composite used in conjunction with a flowable liner at the cervical margin.[9]

Despite the changes in caries treatment brought about by recent advances in adhesive dentistry, polymerization shrinkage is still a major problem with resin composite restorations that manufacturers of dental materials are struggling to address.[26] One recent system developed to minimize polymerization stress, Silorane, uses ring-opening polymerization in place of free-radical polymerization of dimethacrylate monomers. Although some studies have reported silorane-based restorative systems to show marginal integrity and microleakage performance that is superior to methacrylate-based systems,[27,28] a study by Umer *et al.*[20] found no differences between silorane and methacrylate-based systems in terms of sealing ability. Moreover, the literature contains no information regarding the effects of pre-heating silorane-based materials on microleakage. In the present study, no significant differences were observed between the microleakage scores of Aelite LS Posterior and Filtek Silorane. This finding is most likely due to the characteristic features of methacrylate-based nano-filled composites, which are designed to exhibit low levels of shrinkage. Whereas Filtek Silorane has a filler level of 76% and a reported volumetric shrinkage level of less than 1%,[29] Aelite LS Posterior is a highly reinforced methacrylate-based nano-filled composite with a filler level of 74% and a reported volumetric shrinkage level of 1.4%.[30]

CONCLUSION

Within the limitations of the present study, pre-heating was found to reduce the microleakage of methachrylate-based composite used in Class V restorations, but did not affect the microleakage values of Silorane-based composite restorations. Further *in vivo* and *in vitro* studies are needed to better understand the effects of pre-heating on silorane-based resin composite.

REFERENCES

1. Lohbauer U, Zenelis S, Rahiotis C, Petschelt A, Eliades G. The effect of resin composite pre-heating on monomer conversion and polymerization shrinkage. Dent Mater 2009;25:514-9.
2. Leinfelder KF, Bayne SC, Swift Jr EJ. Packable composites: Overview and technical considerations. J Esthet Dent 1999;11:234-9.
3. Lucey S, Lynch CD, Ray NJ, Burke FM, Hannigan A. Effect of pre-heating on the viscosity and microhardness of a resin composite. J Oral Rehabil 2010;37:278-82.
4. Moreira da Silva E, dos Santos GO, Guimaraes JG, Barcellos Ade A, Sampaio EM. The influence of C-factor, flexural modulus and viscous flow on gap formation in resin composite restorations. Oper Dent 2007;32:356-62.
5. Korkmaz Y, Ozel E, Attar N. Effect of flowable composite lining on microleakage and internal voids in class II composite restorations. J Adhes Dent 2007;9:189-94.
6. Deb S, Di Silvio L, Mackler HE, Millar BJ. Pre-warming of dental composites. Dent Mater 2011;27:51-9.
7. Mundim FM, Garcia LF, Cruvinel DR, Lima FA, Bachmann L, Pires-de-Souza FC. Colour srabilty, opacity and degree of conversion of pre-heated composites. J Dent 2011;39 (Suppl 1):e25-9.
8. Daronch M, Rueggeberg FA, De Goes MF. Monomer conversion of pre-heatead composite. J Dent Res 2005;84:663-7.
9. Wagner WC, Aksu MN, Neme AM, Linger JB, Pink FE, Walker S. Effect of pre-heating resin composite on restoration microleakage. Oper Dent 2008;33:72-8.
10. Blalock JS, Holmes RG, Rueggeberg FA. Effect of temperature on unpolymerized composite resin film thickness. J Prosthet Dent 2006;96:424-32.
11. Freedman G, Krejci I. Warming up to composites. Comp Cont Educ Dent 2004;25:371-6.
12. Asmussen E, Peutzfeldt A. Influence of pulse-delay curing on softening of polymer structures. J Dent Res 2001;80:1570-3.
13. Sun J, Fang R, Lin N, Eidelman N, Lin-Gibson S. Nondestructive quantification of leakage at the tooth-composite interface and its correlation with material performance parameters. Biomaterials 2009;30:4457-62.
14. Bayindir YZ, Bayindir F, Zorba YO, Turgut H. Influence of different bonding systems and soft start polymerization on marginal gap formation: Stereological approach. Mater Res Innovat 2008;12:166-71.
15. Kusgoz A, Ülker M, Yesilyurt C, Yoldas OH, Ozil M, Tanrıver M. Silorane-based composite: Dept of cure, surface hardness, degree of conversion, and cervical microleakage in class II cavities. J Esthet Restor Dent 2011;23:324-35.
16. Weinmann W, Thalacker C, Guggenberger R. Silorane in dental composites. Dent Mater 2005;21:68-74

17. Guggenberger R, Weinmann W. Exploring beyond methacrylates. Am J Dent 2000;13:82-4.
18. Alani AH, Toh CG. Detection of microleakage around dental restorations: A review. Oper Dent 1997;22:173-85.
19. Daronch M, Rueggeberg FA, Moss L, De Goes MF. Clinically relevant issues related to preheating composites. J Esthet Restor Dent 2006;18:340-50.
20. Umer F, Naz F, Khan FR. An *in vitro* evaluation of microleakage in class V preparations restorated with Hybrid versus Silorane composites. J Conserv Dent 2011;14:103-7.
21. Radhika M, Sajjan GS, Kumaraswamy BN, Mittal N. Effect of different placement techniques on marginal microleakage of deep class II cavities restored with two composite resin formulations. J Conserv Dent 2010;13:9-15.
22. Heintze SD. Systematic reviews: I. The correlation between laboratory tests on marginal quality and bond strength. II. The correlation between marginal quality and clinical outcome. J Adhes Dent 2007;9:77-106.
23. Chuang SF, Liu JK, Chao CC, Lao FFP, Chen YH. Effect of flowable composite lining and operator experience on micro leakage and internal voids in class II composite restorations. Oper Dent 2001;85:177-83.
24. Daronch M, Rueggeberg Fa, De Goes MF, Giudici R. Polymerization kinetics of pre-heated composite. J Dent Res 2006;85:38-43.
25. Froes-Salgado NR, Silva LM, Kawano Y, Carlos F, Reis A, Loquercio AD. Composite pre-heating: Effects on marginal adaptation, degree of conversion and mechanical properties. Dent Mater 2010;26:908-14.
26. Han B, Dong Y, Gao X, Wang X, Tian F. Effect of filler content on the microtensile bond strength of composite resin and dentin in class I cavities. Quintessence Int 2012;43:16-22.
27. Krifka S, Federlin M, Hiller KA, Schmalz G. Microleakage of silorane- and methacrylate-based composite restorations. Clin Oral Investig 2012;33:740-50.
28. Al-Boni R, Raja OM. Microleakage evaluation of silorane based composite versus methacrylate based composite. J Conserv Dent 2010;13:152-5.
29. Bagis YH, Baltacioglu IH, Kahyaogulları S. Comparing microleakage and the layering methods of siloran-based resin composite in wide class II MOD cavities. Oper Dent 2009;34:578-85.
30. Calheiros FC, Sadek FT, Braga RR, Cardoso PE. Polymerization contraction stres of low-shrinkage composites and its correlation with microleakage in Class V restorations. J Dent 2004;32:407-12.

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