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Original Article

The Effect of Pre-heating Silorane-based Composite Resin on Marginal Gap Formation of Class V Restorations

Alizadeh Oskoee P[a]; Ebrahimi Chaharom ME[b]; Abed Kahnemui M[c]; Mohammadi N[d]; Pournaghi Azar F[e]; Vahedpour H[f]; Saadat M[g]

[a]Professor, Department of operative dentistry, Dental School, Tabriz University of Medical Science, Tabriz, Iran
[b]Associate professor, Department of operative dentistry, Dental School, Tabriz University of Medical Science, Tabriz, Iran
[c]Associate professor, Department of operative dentistry, Dental School, Tabriz University of Medical Science, Tabriz, Iran
[d]Professor, Department of operative dentistry, Dental School, Tabriz University of Medical Science, Tabriz, Iran
[e]Assistant professor, Department of operative dentistry, research center for evidence-based medicine, Dental School, Tabriz University of medical science, Tabriz, Iran
[f]Assistant professor, Department of operative dentistry, Dental School, Urmia University of Medical Science, Urmia, Iran
[g]Postgraduate student, Department of Periodontology, Dental School, Tabriz University of Medical Science, Tabriz, Iran

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Corresponding Author:
Fatemeh Pournaghi Azar,
Assistant professor, Department of operative dentistry, research center for evidence-based medicine, Dental School, Tabriz University of medical science, Tabriz, Iran
Email: pournaghiazar@hotmail.com
Tel: +98-9144069134

Abstract

Statement of problem: Many efforts have been made to solve the problem of composite resin adaptation and reduce microleakage.

Objective: The aim of the present study was to evaluate the effect of preheating of silorane-based composite resins before photo-polymerization on gap formation at the margins of Class V restorations.

Materials and Methods: Standard Class V cavities were prepared on the labial surfaces of 46 sound bovine incisor teeth. The teeth were divided into two groups. In group 1, after application of the bonding agent of the silorane system, the cavities were restored with Filtek silorane-based composite resin stored at room temperature. In group 2, before restoring the cavities, the silorane-based composite resin was heated in a warm water bath at 54ºC for 10 minutes. After 48 hours of storage in distilled water, teeth were thermocycled and sectioned bucco-lingually. Then the gaps of tooth–restoration interfaces in both incisal and gingival margins at three external, middle and internal areas were measured using a stereomicroscope. After calculation of means and standard deviations, data were analyzed with two-factor ANOVA at $\alpha=0.05$.

Results: The mean marginal gaps in non-preheated and preheated groups were 10.66±2.39 and 7.62±2.05 µm, respectively, with a statistically significant difference ($P<0.001$). However, the differences between the occlusal and gingival margins in each group were not significant ($P=0.58$). The interactive effect of preheating and margin type was not significant ($P=0.10$).

Conclusions: Heating silorane-based composite resin before light curing resulted in decreasing the gap sizes at tooth–restoration interfaces in Class V cavities.

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Introduction

Despite the ever-increasing interest in using composite resins to restore tooth cavities [1], these materials still has some shortcomings including polymerization shrinkage, poor proximal contacts and adaptation with the cavity walls in some clinical conditions [2]. In Class V cavities, especially in cervical margins located in dentin, polymerization shrinkage might result in marginal gaps formation. This would cause recurrent caries, pulpal irritation, sensitivity and marginal discoloration [3].However, in order to improve the mechanical properties of composite resins modifications have been made in the size, shape and distribution of inorganic fillers and increased filler content to improve the mechanical properties of composite resins, which results in enhanced viscosity and difficulty in manipulating and proper adapting of these composite resins[4].

Many efforts have been made to solve the adaptation problem and reduce microleakage, including utilizing flowable composite resins, composite liners [2, 4], and composite inlays and onlays [3]. Flowable composite resins are not as durable as high viscous composite resins due to lower filler content. The second and third mentioned methods complicate the procedural steps [5].

In recent years, low-shrinkage resin materials that are synthesized based on siloxane and oxirane molecules' chemistry have been introduced to overcome the problems resulting from polymerization shrinkage [6]. Mitthra *et al*.[7] showed that silorane exhibited less polymerization shrinkage and shrinkage stress compared to methacrylates. Also in their study, silorane and nanohybrid composite resin showed greater wear resistance compared to microhybrid [7]. Sivakumar *et al*. [8] evaluated the microleakage of restorations using silorane-based dental composite resin and showed that in general, silorane-based microhybrid composite had less microleakage among the other materials used in this in vitro study.

Recently, many studies has reported that preheating composite resins decreases viscosity and film thickness, which enhances flowability and adaptation with the cavity walls [9-14].

Choudhary *et al* [2], reported that preheating the composite resin up to 54ºC improves adaptation and decreases the total amount of gaps. Dionysopoulos *et al*. [15] showed that preheating of conventional composite resins at 54ºC and 60ºC reduces their film thickness, independent of the type of composite resin. Moreover, nano-hybrid and bulk fill composite resins exhibit the greatest reduction and microhybrid and packable exhibit the lowest reduction in film thickness [15]. Temperature affects the kinetics of composite resin polymerization and increases the conversion rate, as well as reduces viscosity [16] through enhancing the motility of molecules and free radicals [17-18].When the conversion rate of resin monomers increases, the polymerization shrinkage and consequently stresses may increase [19-20]. The relationship between the conversion rate and an increased temperature has been studied in a wide range of composite resin systems [21-26]. In the majority of these studies, the effect of heating methacrylate-based composite resins has been evaluated.

The importance of the interfacial bond between composite resin and the cavity walls, and the differences in the chemical structure and polymerization process in silorane-based composite resins that can possibly affect the behavior of these composite resins when preheated is concerned. Therefore, the present study was conducted to evaluate the effect of preheating silorane-based composite resins on gap formation at the gingival and occlusal margins of Class V restorations.

Materials and Methods

A list of materials used in the present study along with the properties of each material is summarized in table 1.

In the present in vitro study, 46 sound bovine incisors without any carious lesions, cracks, fractures or anomalies in the bucco-gingival region were used. The teeth were cleaned using pumice powder and rubber cups before the study and stored in 0.5% chloramine solution. Standard Class V cavities (2 mm in depth, 2 mm mesio-distally and 3 mm occluso-gingivally) were prepared on the buccal surfaces, with the occlusal and gingival margins 1.5 mm coronal and apical to the CEJ respectively(Figure1), using a sharp diamond fissure instrument in high-speed handpiece under

Table 1: The materials and devices used in the present study		
Material	**Description & Composition**	**Manufactured by**
FiltekTM Silorane, low-shrink posterior restorative	A light-curing radiopaque silorane-based composite; the monomer matrix is composed of siloxane and oxirane (23% of the composition). The inorganic filler contains fine quartz particles and radiopaque yttrium fluoride (76%). Additional contents: initiator (0.9%), stabilizer (0.13%) & pigments (0.005%).	3M ESPE Dental Product USA
FiltekP90 system adhesive	A filled, light-cured component bonding agent for enamel and dentin bonding. It contains a 3M ESPE hydrophobic bifunctional monomer, camphoroquinine/ a silane-treated silico fillers, stabilizer.	3M ESPE Dental Product USA
Astralis 7	8-mm light probe	IvoclarVivadent, Liechtenstein, Austria
Stereomicroscope, SMZ1000	Parallel Optical Zoom System Zoom Range:×0.8 to ×8.0	Nikon, Tokyo,Japan
Diamond bar	TR-25F (ISO 199/016)	Japan

Figure 1: Class V Cavity preparation on Bovine incisor 2 mm in depth, 2 mm mesio-distally and 3 mm occluso-gingivally

air and water coolant[24].

After preparation of standard cavities, the samples were randomly assigned to two groups of 23. In the group 1, after irrigating and drying the cavities, the primer and bonding of the silorane adhesive system were applied according to manufacturer's instructions and the cavities were restored with Filtek silorane-based composite resin. They were then light-cured for 40 seconds with a tungsten halogen light-curing unit (Astralis 7; Ivoclar Vivadent, Liechtenstein, Austria) at a light intensity of 500 mW/cm2 and light-conducting tip with 8 mm light probe and perpendicular to the composite resin surface. In group 2, before restoring the cavities, Filtek silorane-based composite resin was placed in a warm thermostatically-controlled water bath(TELEDYNE HANAU, Buffalo, NY, USA) at a temperature of 54ºC for 10 minutes and used to restore the cavities immediately after being retrieved from the warm environment[2]. The restorations were polished by using a diamond instrument (DiamantGmbh, D&Z, Berlin, Germany) and polishing disks (Sof-Lex TM, 3M ESPE Dental Products, St. Paul, USA) and stored in distilled water at room temperature for 48 hours. In order to simulate the oral cavity conditions, the samples underwent a thermocycling procedure in a water bath consisting of 500 cycles at 5/55ºC, with a dwell time of 30 seconds and a transfer time of 10 seconds[25].

Subsequently, the samples were sectioned bucco-lingually by using diamond disks (Diamant Gmbh, D&Z, Berlin, Germany). Marginal gaps were measured using a stereomicroscope (SMZ 1500; Nikon, Tokyo, Japan) at 40× magnification. A digital camera was employed to photograph the selected areas with the use of a DS-L2 control unit

(Nikon, Tokyo, Japan). Therefore, the gaps could be measured at occlusal and gingival margins of the cavities in 3 points (Figure 2).

The gap widths were measured by using the built-in software (DS-L2 Ver 441, Nikon, Japan) in µm by determining two points on each side of the gap (one on the restoration side and one on the root side) and measuring the distance between these two points. Data were analyzed using two-way ANOVA and paired sample t- test at α=0.05.

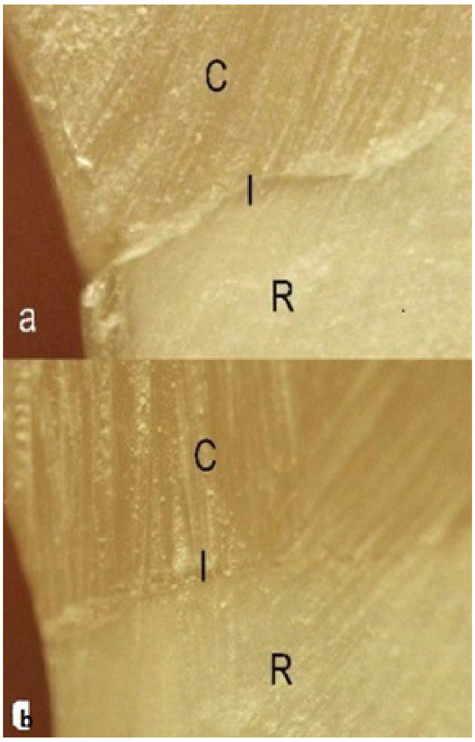

Figure 2: Marginal gap measurement (µm) with the use of the specific software program of the stereomicroscope at 40× magnification a: non-preheated,b: preheated
C: composite, I:interface,R:root

Results

Table 2 presents the means and standard deviations of marginal gap width of the study groups. The means of marginal gap width in the group 1 (non-preheated) and the group 2 (preheated) were 10.66±2.39 and 7.62±2.05µm, respectively. The results of Two-way ANOVA showed significant differences in marginal gap width of both occlusal and gingival margins between the preheated and non-preheated groups ($P<0.001$).

Paired sample t- test showed that there were no significant differences in marginal gaps between occlusal and gingival margins within each group ($P=0.58$). Two way Anova test showed that the interactive effect of preheating and margin type was not statistically significant ($P=0.10$).

Discussion

In the present study, the effect of preheating of silorane-based composite resin before photo-polymerization on the gap formation (at tooth–restoration interfaces) in Class V cavities was evaluated. Based on the results, the mean size of the marginal gaps at both the occlusal and gingival margins in the preheated group was significantly less than that in the control (non-preheated) group. Similarly, Fores-Salgado *et al*. [26] reported that marginal adaptation improved when composite resin was preheated. Furthermore, Choudhary *et al*. [2] showed that less marginal gaps were formed when composite resin was heated up to 54ºC compared to composite resin at room

Table 2: The descriptive table (Mean±SD) of the gap width values (µm) in study groups

Margin / Group	Occlusal	Gingival	N	P value(inter group)
Preheated	7.06±1.03	8.14±2.04	23	0.58
Non-preheated	12.91±2.56	12.57±1.45	23	0.58
P value (intra group)	0.0001*	0.0001*		

*Statistically significant

temperature or at 37ºC.Demmirbuga *et al*.[27] investigated the effect of preheating on microshear bond strength of silorane and methacrylate-based composite resins to human dentin. They concluded that preheating of composite resins might be an alternative way to increase the micro-shear bond strength of composites on dentin. This finding is most likely due to increased flow and consequently better marginal adaptation to the dentin surface, which results in reduced marginal gap width [27]. However, Arslan *et al*.[6] showed that Pre-heating reduced microleakage values of Aelite LS Posterior composite, but did not significantly alter the microleakage values of Filtek Silorane composite. Alizadeh *et al*. [28] showed that repeated preheating of dimethacrylate and silorane-based composite resins decreased the marginal gap formation in class V restorations. Preheating occurs when heating composite resin up to a specific temperature before placing it in the cavity [5, 6]. Based on literature, heating composite resin decreases its viscosity by increasing molecular motility [14], therefore; as a result, the flow increases and the adaptation of the material with the cavity walls and wetting of the angled areas improves [6]. Wagner *et al*. [5] showed that preheating composite resin could improve its adaptation with tooth structures. Despite the advantages mentioned above, Lohbourer *et al*.[29] reported that preheating composite resin might have a deleterious effect on the margins of composite resin due to enhanced polymerization shrinkage .

Considering the mechanical properties of preheated composite resins, some previous studies have reported an increased conversion rate and subsequently increased polymerization shrinkage [1,17-18]. Also, the thermal expansion coefficient of composite resin is 6–8 times greater than surrounding tooth structure [30] that along with polymerization shrinkage results in interfacial stresses in preheated composite resin that might affect adaptation, seal and the marginal integrity [31]. Elhejazi *et al*. [32] suggested a delay of 15 s before light curing to solve such a problem. Zhao *et al*. [33] showed that a delay in light-curing preheated composite resin results in decreasing the temperature at which the conversion rate is not affected, whereas the temperature is high enough to allow better wetting of the cavity walls. In clinical conditions and also in the present study, there was an interval between transferring the composite resin to the cavity, shaping and curing. It has been estimated that when composite resin is heated up to 60ºC, its temperature drops 35-40% within 40 seconds after removal from the warm environment, with a decrease of 50% after 2 minutes [6]. Based on the results of the present study, it can be concluded that when the preheated composite resin is light-cured, its temperature reaches a level that is adequate for enhancing flow and adaptation; however, it is not adequate for increasing conversion rate, polymerization shrinkage and other mechanical properties. Deb *et al*. [31] showed that in non-isothermal conditions, the possible increased polymerization shrinkage due to temperature rise could be compensated by enhanced flow. Sharafeddin *et al*. [34] showed that flexural strength and flexural modulus of silorane based composites improved when preheating at 45˚C. These two mechanical properties are fundamental for brittle materials and along with better adaptation can affect the clinical performance.The results of the present study showed that there was no significant difference in the mean gap width between the occlusal and cervical gaps in each study group, contrary to some previous studies which have shown less microleakage at occlusal margins compared to gingival margins [5, 27]. However, Deb *et al*. [31] showed no significant differences between incisal and cervical margins. Formation of marginal gap is influenced by the amount of composite resin polymerization shrinkage and presence of enamel margin and the cavity geometry [5]. In the present study, a low shrinkage composite resin was selected. The results of the study showed that using silorane-based composite resin and enhanced flow might have mitigated the negative effects of composite resin polymerization shrinkage on the occlusal and gingival margin integrity since there were no statistically significant differences between the two margins. In addition, previous studies have shown that silorane-based composite resins have better marginal integrity and performance compared to methacrylate-based composite resins [6].

Conclusions

Silorane based composite showed better marginal adaptation when preheated due to low viscosity and wetting ability. However, there was no significant difference between occlusal and gingival margins.

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Conflict of Interest: None declared.

References

1. Uctasli MB, Arisu HD, Lasilla LVJ, *et al*. Effect of preheating on the mechanical properties of resin composites. Eur J Dent. 2008; 2: 263-268.
2. Choudhary N, Kamat S, Mangala TM, *et al*. Effect of pre-heating composite resin on gap formation at three different temperatures. J Conserv Dent. 2011; 14: 191-195.
3. Acquaviva PA, Cerutti F, Adami G, *et al*. Degree of conversion of three composite materials employed in the adhesive cementation of indirect restorations: a micro-Raman analysis. J Dent. 2009; 37: 610-615.
4. Nada K, El-Mowafy O. Effect of precuring warming on mechanical properties of restorative composites. Int J Dent. 2011; 2011: 1-5.
5. Wagner WC, Aksu MN, Neme AM, *et al*. Effect of pre-heating resin composite on restoration microleakage. Oper Dent. 2008; 33: 72-78.
6. Arslan S DS, Zorba YO, Ucar FI, *et al*. The effect of pre-heating silorane and methacrylate-based composites on microleakage of class V restorations. Eur J Gen Dent. 2012; 1: 178-182.
7. Mitthra S, Rajkumar K, Mahalaxmi S . Evaluation of polymerization shrinkage, polymerization shrinkage stress, wear resistance, and compressive strength of a silorane-based composite: A finite element analysis study. Indian J Res Dent. 2017; 28:375-379.
8. Sivakumar JS, Prasad AS, Soundappan S, *et al*. A comparative evaluation of microleakage of restorations using silorane-based dental composite and methacrylate-based dental composites in Class II cavities: An in vitro study. J Pharm Bioallied Sci. 2016; 8:S81-S85.
9. Daronch M RF, Moss L, De Goes F. Clinically relevant issues related to preheating composites. Esthet Restor Dent. 2006; 18: 340-351.
10. Blalock JS,Holmes RG, Rueggeberg FA. Effect of temperature on unpolymerized composite film thickness. J Prosthet Dent. 2006; 96: 424-432.
11. Knight JS,Fraughn R, Norrington D. Effect of temperature on the flow properties of resin composite. Gen Dent.2006; 54: 14-16.
12. Freedman G, Krecji I. Warming up to composites. Compend Contin Educ Dent 2004; 25: 371-374.
13. Freedman PD. Clinical benefits of pre-warmed composites. Private Dent. 2003; 8: 111-114.
14. Daronch M,Rueggeberg FA, De Goes MF, *et al*. Polymerization kinetics of pre-heated composites. J Dent Res. 2006; 85: 38-43.
15. Dionysopoulos D, Tolidis K, Gerasimou P, *et al*. Effect of preheating on the film thickness of contemporary composite restorative materials. J Dent Sci. 2014; 9:313–319.
16. Daronch M, Rueggeberg FA, De Goes MF. Monomer conversion of preheated composite. J Dent Res.2005; 84: 663-667.
17. Trujillo M NS, Stansbury JW. Use of near-IR to monitor the influence of external heating on dental composite photopolymerization.Dent Mater. 2004;20:760-777.
18. Labella R. Lambrechts P, Van Meerbeek B, *et al*. Polymerization shrinkage and elasticity of flowable composites and filled adhesives. Dent Mater. 1997; 15:128-137.
19. Duarte S Jr, Botta AC, Meire M, *et al*. Microtensile bond strength & scanning electron microscopic evaluation of self-adhesive and self-etch resin cements to intact & etched enamel.J Prosthet Dent. 2008; 100: 203-210.
20. Lovell LG, Lu H, Elliott JE, *et al*. The effect of cure rate on the mechanical properties of dental resins. Dent Mater. 2001; 17: 504-511.
21. Lovell LG, Newman SM, Bowman CN. The effect of light intensity, temperature and comonomer composition on the polymerization behavior of dimethacrylate dental resins.J Dent Res. 1999; 78: 1469-1476.
22. Asmussen E. Factors affecting the color

stability of restorative resins. Acta Odontol Scand. 1983; 41: 11-18.

23. Schneider LF, Pfeifer CS, Consani S, *et al*.Influence of photoinitiator type on the rate of polymerization, degree of conversion, hardness and yellowing of dental resin composites. Dent Mater. 2008; 24: 1169-1177.
24. Sensi LG, Marson FC, Baratieri LN, *et al*. Effect of placement techniques on the marginal adaptation of class V composite restorations. Contemp Dent Pract. 2005; 6:17-25.
25. Buonocore MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. J Dent Res. 1995; 34: 849-853.
26. Froes- Salgado NR, Maria SL, Kawano Y, *et al*.Composite pre-heating: Effects on marginal adaptation, degree of conversion and mechanical properties.Dent Mater.2010; 26: 908-914.
27. Demirbuga S, Ucar FI, Cayabatmaz M, *et al*. Microshear bond strength of preheated silorane- and methacrylate-based composite resins to dentin. Scanning. 2016; 38:63-9.
28. Alizadeh Oskoee P, Pournaghi Azar F, Jafari Navimipour E,*et al*. The effect of repeated preheating of dimethacrylate and silorane-based composite resins on marginal gap of class V restorations. J Dent Res Dent Clin Dent Prospects. 2017; 11:36-42.
29. Lohbauer U, Zenelis S, Rahiotis C, *et al*.The effect of resin composites pre-heating on monomer conversion and polymerization shrinkage. Dent Mater. 2009; 25:514-519.
30. Sidu SK, Carrick TE, McCabe JF. Temperature mediated coefficient of dimensional change of dental tooth-colored restorative materials. Dent Mater. 2004; 20: 435-440.
31. Deb S, Di Silvio L, Mackler HE, *et al*. Pre-warming of dental composite. Dent Mater. 2011; 27: e51-e59.
32. Elhejazi AA. The effects of temperature and light intensity on the polymerization shrinkage of light-cured composite filling materials. J Contemp Dent Pract. 2006; 7:12–21.
33. Zhao S, Qian Y, Liu H, *et al*. The effect of preheating on light cured resin composites. J Hard Tissue Biol 2012; 21:273-2788.
34. Sharafeddin F, Motamedi M, Fattah Z. Effect of Preheating and Precooling on the Flexural Strength and Modulus of Elasticity of Nanohybrid and Silorane-based Composite. J Dent (Shiraz). 2015;16:224-9.