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

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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 α=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.

Introduction

Despite the ever-increasing interest in using composite resins to restore tooth cavities [1], these materials still have 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 54°C improves adaptation and decreases the total amount of gaps. Dionysopoulos et al. [15] showed that preheating of conventional composite resins at 54°C and 60°C 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 (Figure 1), using a sharp diamond fissure instrument in high-speed handpiece under
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 54°C 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 (Diamant GmbH, D&Z, Berlin, Germany) and polishing disks (Sof-Lex™, 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 5/55°C, with a dwell time of 30 seconds and a transfer time of 10 seconds[25].

Subsequently, the samples were sectioned buccolingually by using diamond disks (Diamant GmbH, D&Z, Berlin, Germany) and polishing disks (Sof-Lex™, 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 5/55°C, with a dwell time of 30 seconds and a transfer time of 10 seconds[25].

Subsequently, the samples were sectioned buccolingually 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.

Table 1: The materials and devices used in the present study

<table>
<thead>
<tr>
<th>Material</th>
<th>Description &amp; Composition</th>
<th>Manufactured by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filtek™ Silorane, low-shrink</td>
<td>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%) &amp; pigments (0.005%).</td>
<td>3M ESPE Dental Product USA</td>
</tr>
<tr>
<td>posterior restorative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FiltekP90 system adhesive</td>
<td>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.</td>
<td>3M ESPE Dental Product USA</td>
</tr>
<tr>
<td>Astralis 7</td>
<td>8-mm light probe</td>
<td>IvoclarVivadent, Liechtenstein, Austria</td>
</tr>
<tr>
<td>Stereomicroscope, SMZ1000</td>
<td>Parallel Optical Zoom System Zoom Range:×0.8 to ×8.0</td>
<td>Nikon, Tokyo, Japan</td>
</tr>
<tr>
<td>Diamond bar</td>
<td>TR-25F (ISO 199/016)</td>
<td>Japan</td>
</tr>
</tbody>
</table>
Effect of pre-heating silorane-based composite on marginal gap formation

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.

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 54°C compared to composite resin at room temperature.

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

<table>
<thead>
<tr>
<th>Group</th>
<th>Margin</th>
<th>Occlusal</th>
<th>Gingival</th>
<th>N</th>
<th>P value (inter group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preheated</td>
<td>Occlusal</td>
<td>7.06±1.03</td>
<td>8.14±2.04</td>
<td>23</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>Gingival</td>
<td>12.91±2.56</td>
<td>12.57±1.45</td>
<td>23</td>
<td>0.58</td>
</tr>
<tr>
<td>P value (intra group)</td>
<td></td>
<td>0.0001*</td>
<td>0.0001*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Statistically significant
temperature or at 37°C. 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 60°C, 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.

Acknowledgements

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Conflict of Interest: None declared.

References

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