Microleakage of different resin composite types

A. Rüya Yazici, DDS, PhD1/Çiğdem Çelik, DDS2/Gül Özgünaltay, DDS, PhD3

Objective: The purpose of this study was to evaluate the microleakage of Class V cavity preparations restored with three different types of resin composite and an ormocer. Method and materials: Forty Class V cavities were prepared in buccal and lingual surfaces of 20 recently extracted molar teeth. The occlusal margin of each restoration was on enamel and the gingival margin on dentin. Teeth were randomly assigned to four groups of 5 teeth each and restored as follows: Group I, flowable resin composite (Tetric Flow); Group II, hybrid resin composite (Z100); Group III, packable resin composite (Solitaire 2); Group IV, organically modified ceramics-ormocer (Admira). In all groups, the manufacturers’ instructions were strictly followed. All restorative resin composite materials were placed in one increment. All teeth were then immersed in 0.5% basic fuchsin solution for 24 hours after thermocycling (200 cycles; between 4°C to 60°C). The teeth then were longitudinally sectioned and observed under a stereomicroscope. The degree of dye penetration was recorded and analyzed with the Kruskal-Wallis and Mann-Whitney tests.

Results: No statistically significant differences in microleakage were observed between groups either on enamel or dentin.

Conclusion: All restorative materials demonstrated equal effectiveness in reducing microleakage.

(Qintessence Int 2004;35:790-794)

Key words: Class V cavity, flowable resin composite, hybrid resin composite, microleakage, ormocer, packable resin composite

CLINICAL RELEVANCE: Although the restorative materials investigated in this study completely prevented leakage on enamel, all groups except ormocers showed some degree of leakage on the dentin margin. No restorative material was superior to another in preventing microleakage in dentin.

There is a widespread use of resin composite for the restoration of cervical lesions. The type of restorative materials is thought to play an important role in clinical longevity of Class V restorations. The amount and size of filler particles determine the type of resin composite. Resin composites contain filler, which increases strength and modulus of elasticity and reduces polymerization shrinkage, the coefficient of thermal expansion and water sorption.

Since 1996, a new type of resin composite described as “flowable” has become popular. Compared with hybrids, the particle size is increased and the filler amount is decreased in flowable resin composites. They have commonly been used for restoration of minimally invasive cavity preparations, Class V cavities, and as a stress-breaking base material under hybrid or packable resin composites because of their lower elastic modulus.

In recent years, packable resin composites have attracted increasing attention in restorative dentistry. They are a new class of highly filled composites with a filler distribution that gives them a different consistency compared with hybrid resin composites. Packable composites generally have larger than average filler particles, and the resin matrix is modified chemically to allow a slight increase in filler amount. Manufacturers claim that this class of resin composites may be used in posterior restorations as an alternative to amalgam restorations.
TABLE 1 Resin composites and compositions

<table>
<thead>
<tr>
<th>Product</th>
<th>Composition</th>
<th>Filler volume (%)</th>
<th>Average filler particle size (μm)</th>
<th>Volumetric polymerization shrinkage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetric Flow</td>
<td>bis-GMA, UDMA, TEGDMA</td>
<td>39.7</td>
<td>0.04 to 3.0</td>
<td>3.25</td>
</tr>
<tr>
<td>Z100</td>
<td>bis-GMA, TEGDMA</td>
<td>66.0</td>
<td>0.60</td>
<td>2.80</td>
</tr>
<tr>
<td>Solitaire 2</td>
<td>bis-GA, TEGDMA, UDMA, tetrafunctional monomers</td>
<td>58.0</td>
<td>0.20 to 20</td>
<td>2.90</td>
</tr>
<tr>
<td>Admira</td>
<td>Anorganic-organic copolymers (ormocers) additive aliphatic and aromatic dimethacrylates</td>
<td>56.0</td>
<td>0.70</td>
<td>1.97</td>
</tr>
</tbody>
</table>

*Note: bis-GMA = bisphenol glycidyl methacrylate; UDMA = urethane dimethacrylates; TEGDMA = triethylene glycol dimethacrylate; bis-GA = bisphenol glycidyl acrylate.*

Another new approach in restorative dentistry has been the introduction of ormocers (organically modified ceramics) in 1998. Instead of bisphenol glycidyl methacrylate (bis-GMA), urethane dimethacrylate (UDMA), and triethylene glycol dimethacrylate (TEGDMA), multifunctional urethane- and thioether(meth)acrylate alkoxysilanes as sol-gel precursors have been developed for the synthesis of inorganic-organic copolymer ormocer resin composites as dental restorative materials. The alkoxysilyl groups of the silane allow the formation of an inorganic Si-O-Si network by hydrolysis and polycondensation reactions, and the (meth)acrylate groups are available for photochemically induced organic polymerization. After incorporation of filler particles, the ormocer composites can be manipulated like hybrid composite.15

The major drawback of resin composites is the polymerization shrinkage.14-16 Contraction during polymerization produces stress between the restoration and tooth interface and may result in marginal openings, which promote microleakage.7 However, polymerization shrinkage usually does not cause significant problems with restorations having all enamel margins, as enamel is a reliable substrate for bonding.9 Bonding to dentin is more difficult to achieve due to the specific properties of dentin, such as the tubular structure and intrinsic wetness.18,19 In this manner, the longevity of resin composite restorations may not be very satisfactory for cervical cavities, as they generally have dentin margins.

The aim of this study was to evaluate the in vitro microleakage of Class V cavities with cervical margin in dentin using different types of resin composites and an ormocer.

**METHOD AND MATERIALS**

Twenty extracted human molars free of visible caries, cracks, and restoration were selected for this study. They were stored in an aqueous 1% choloramin T solution before use within 1 month after extraction. The teeth were cleaned using scalers and pumice. Class V type cavities were prepared on the buccal and lingual surfaces of each tooth using an 855-010-4 ML cylindrical diamond bur (Diatech Dental) under air-water cooling. The bur was replaced after every four preparations. The preparations measured 3 mm long, 2 mm wide, and 1.5 mm deep, with the gingival margin in dentin and the occlusal margin in enamel. After etching enamel and dentin (total-etch) with 37% phosphoric acid for 20 seconds, the cavities were thoroughly washed with water and slightly air-dried to achieve a slightly moist cavity surface without pooled water (wet bonding). All prepared teeth were randomly divided into four groups of five teeth (10 cavities). The three types of resin composite used were a flowable resin composite (Tetric Flow), a hybrid resin composite (Z100), a packable resin composite (Solitaire 2), and an ormocer (Admira) (Table 1). Each of these groups received a different restorative material with their accompanying adhesive system and each was used according to its manufacturer's recommendations, with special attention to avoid desiccation of dentin (Table 2).

The restorative materials were placed in one increment, since the depths were less than 2 mm. All preparations of teeth, restoration, and finishing were performed by one operator. After storage in water at 37°C for 24 hours, the restorations were finished with fine-grit finishing diamond burs (Diatech) and polished with a graded series of flexible discs (Sof-Lex, 3M).

All restored teeth were stored in deionized water for 1 week. The specimens were then thermocycled for 200 cycles between 4°C and 60°C for 1 minute in each bath with a 10-second transfer time. The apex of each tooth was sealed with resin composite (Spectrum TPH, Dentsply de Trey), and the whole tooth, except 1 mm beyond the margin of the restoration, was coated with two layers of nail varnish. All teeth were immersed in 0.5% basic fuchsia dye solution for 24 hours.
TABLE 2 Bonding procedures

<table>
<thead>
<tr>
<th>Group</th>
<th>Resin composite</th>
<th>Adhesive system</th>
<th>Dentin pretreatment</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Tetric Flow (batch no. D07429)</td>
<td>Excite (batch no. C45074)</td>
<td>Apply adhesive for 10 seconds; air dry gently; light cure for 20 seconds</td>
<td>Vivadent</td>
</tr>
<tr>
<td>II</td>
<td>Z100 (batch no. 5540)</td>
<td>Single Bond (batch no. 4400198044)</td>
<td>Apply two consecutive coats of adhesive; air dry gently for 2 to 5 seconds; light cure for 10 seconds</td>
<td>3M</td>
</tr>
<tr>
<td>III</td>
<td>Solitaire 2 (batch no. 100230)</td>
<td>Glima Comfort Bond (batch no. 070039)</td>
<td>Apply two consecutive coats of adhesive for 15 seconds; air dry gently for 3 to 15 seconds; light cure for 20 seconds</td>
<td>Heraeus Kulzer</td>
</tr>
<tr>
<td>IV</td>
<td>Admira (batch no. 22525)</td>
<td>Admira Bond (batch no. 22637)</td>
<td>Apply adhesive for 30 seconds; air dry gently; light cure for 20 seconds</td>
<td>Voco</td>
</tr>
</tbody>
</table>

TABLE 3 Distribution of dye penetration scores at the occlusal and gingival margins

<table>
<thead>
<tr>
<th>Group</th>
<th>Materials</th>
<th>Leakage</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (flowable composite)</td>
<td>Tetric Flow/Excite</td>
<td>0 3</td>
</tr>
<tr>
<td>II (hybrid composite)</td>
<td>Z100/Single Bond</td>
<td>0 1</td>
</tr>
<tr>
<td>III (packable composite)</td>
<td>Solitaire 2/Glima Comfort Bond</td>
<td>0 1</td>
</tr>
<tr>
<td>IV (ormocer)</td>
<td>Admira/Admira Bond</td>
<td>0 0</td>
</tr>
</tbody>
</table>

at room temperature and rinsed under tap water. The teeth were sectioned longitudinally through the center of each restoration with a slow-speed diamond saw (Isomet, Buehler). The section with greater leakage was evaluated blindly and independently by two examiners with a stereomicroscope (M9, Wild Heerbrugg) at ×20 magnification to determine the extent of dye penetration. Scoring was done according to the following criteria at the occlusal and gingival margins:

- 0 = no dye penetration
- 1 = dye penetration to less than half the cavity depth
- 2 = dye penetration to more than half the cavity depth
- 3 = dye penetration to the axial wall and beyond

The nonparametric data were analyzed using Kruskal-Wallis analysis of variance by ranks at the .05 level of significance. A Mann-Whitney U test was used to compare the differences between groups (P < .05).

RESULTS

Table 3 shows the distribution of dye penetration scores at the occlusal and gingival margins in all four groups. There was no statistical difference in microleakage at the occlusal margins located in enamel (P = 1.000) and gingival margins located in dentin (P = .237) in any of the groups. None of the restorative materials showed microleakage at the occlusal margins. While Admira group's specimens completely resisted leakage at the gingival margins, one specimen from Z100, one specimen from Solitaire 2, and three specimens from Tetric Flow showed penetration of dye to less than half the cavity depth.

Comparing the microleakage scores between enamel and dentin margins within each restorative material, there was a slight increase in dentin margins but was not statistically significant.

DISCUSSION

Proper adhesion between restorative materials and the cavity walls results in good marginal sealing, less microleakage, and longer life of the restoration. However, bonding to dentin is far more difficult and less predictable than bonding to enamel because dentin is inorganic in nature, about 75%, as opposed to enamel, which is 95% inorganic.20-22 Moreover, dentin has a more complex histologic structure. In the present study, while all of the restorations prevented microleakage totally at the occlusal margins, most of them exhibited microleakage at the gingival margin located in dentin. The difference in composition between the enamel and dentin may have accounted for the fact that the dentin showed more leakage.

However, the difference was insignificant as there was only a slight increase in leakage scores in dentin margins. This finding is in disagreement with previous investigations, which demonstrated that the leakage in dentin margins is statistically higher than leakage in enamel margins.23 In the present study, the absence of statistically significant differences between occlusal and gingival margins could be attributed to the high and reliable dentin bond strength of the used adhesives. It has been generally accepted that the gaps between restorative material and cavity walls generally
occurs when the bonding capacity of the adhesive system is insufficient to resist the forces of polymerization shrinkage of the composite.\textsuperscript{24}

Resin composite restorations show significant differences in the resin matrix composition as well as in the filler, which influences the properties of the materials, including polymerization shrinkage.\textsuperscript{25-28} The results of this study showed that all restorative materials had similar microleakage scores to each other in gingival margins, but slightly less than flowable resin composite. Although statistically insignificant, the difference between the leakage scores in dentin can be attributed to the polymerization contraction of resin composite materials. Comparing the four materials tested, Admira (ormocer) showed the best results both in enamel and dentin. The complete resistance of Admira to microleakage in dentin margins could be related to its high filler load, which withstands the polymerization contraction stress. Admira’s polymerization shrinkage of 1.97\% by volume is the lowest value among the other restorative materials. Because of their three-dimensional structure and extremely high molecular weight, ormocers might undergo less shrinkage.

Flowable composites have been suggested as more flexible restorative material that helps to absorb the stresses caused by tooth flexure.\textsuperscript{29,30} Therefore, a lower modulus of elasticity of flowables is thought to lead to greater success in Class V cavities. Opposite to this statement, Tetric Flow showed the most extensive dye penetration in the present study. This may be due to less filler content, which leads to greater polymerization shrinkage stresses. Contrary to these findings, Fritschi et al.\textsuperscript{31} demonstrated that the use of a restorative material with a low modulus of elasticity reduced microleakage. They found that hybrid resin composites exhibited more microleakage than microfilled and flowable composites and suggested that the elasticity of resin composite materials might be a factor in the amount of microleakage in cervical restorations. The findings of this research are consistent with those found by Estafan and Estafan\textsuperscript{32} who compared different flowable composites with hybrid composite and concluded that all flowable composites demonstrated similar microleakage resistance properties to hybrid composite in Class V cavities. In a study by Fritschi et al.,\textsuperscript{25} no difference in microleakage between a highly filled hybrid resin composite and less-filled microfilled resin composite was determined. Yazici et al.\textsuperscript{33} also demonstrated similar leakage by flowable and hybrid composites.

On the other hand, Jang et al.\textsuperscript{34} showed no significant differences between flowable and packable composites in terms of microleakage. It should be noted that the teeth used in the present study were not subjected to load cycling. Under load cycling, they might have shown better results due to their properties. However, some authors have reported on the lack of effect of load cycling on microleakage.\textsuperscript{35,36}

An increase in the percentage of filler causes a decrease in the material flow and volume contraction. Z100 and Solitaire 2 have approximately the same volume percentage of filler, and therefore, their leakage patterns were the same, as only one specimen from each restorative material group showed leakage less than half of the cavity depth. According to the results obtained in a previous in vitro study, Meiers et al.\textsuperscript{37} also found similar leakage patterns with packable and hybrid resin composite.

Some reports recorded increased microleakage of restoratives with less filler loads while others showed opposite results. Such variation in reported findings may be due to differences in materials used, cavity types and sizes, and operators.

Since these results were obtained in vitro, long-term clinical trials are needed to fully understand the performance of these newly developed resin composite materials.

CONCLUSION

The results of the present study revealed no statistically significant differences between the restorative materials tested either on enamel or dentin. All of the restorative materials in the study demonstrated complete leakage resistance on enamel and similar leakage resistance on dentin margins.

ACKNOWLEDGMENTS

The authors would like to thank Erdem Karabulut for his support with the statistical analysis. The ormocer used in this study was generously supplied by Voco.

REFERENCES


