Microleakage of class II packable resin composite lined with flowable composite and resin modified glass ionomer cement: An in vitro study

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ABSTRACT
Background: Packable composites most commonly used as posterior restorative materials, however, disadvantages like polymerization shrinkage limited their use, so the aim of this in vitro study was to investigate the microleakage of posterior packable composite (Filtek™ P-60) using different liner materials; flowable resin composite (Filtek™ Flow) and resin modified glass ionomer cement (Vitrebond™ 7150) using open sandwich technique at the proximal box of class II preparation located above the cemento-enamel junction (CEJ) in enamel.

Materials and Methods: Twenty four recently extracted human upper premolars were prepared with standardized Class II cavities as follows; Occlusal Outline Form: 2mm in bucco-lingual width and 1.5 mm in depth measured from occlusal fissure to pulpal floor. Proximal Boxes: The depth of the proximal box from the proximal cavo-surface margin to the axial wall was 2mm, so as the bucco-lingual width (2mm). The proximal box margin located 1 mm coronal to the CEJ (in enamel). The teeth were assigned into 3 groups (n=8): Group-I (control): acid etching (HH₃PPO₄₄) + bonding agent (Adoper Single Bond 2 Adhesive) + posterior packable composite (Filtek™ P-60), Group-II (RMGIC): acid etching + resin modified glass ionomer cement (Vitrebond™ 7150) + posterior packable composite; Group-III (Flowable): acid etching + bonding agent + flowable composite (Filtek™ Flow) + posterior packable composite. The teeth were immersed in distilled water at 37°C for 24 h., then thermocycled (1000X, 5°-55°C, 30 sec. dwell time) and immersed in 1% methylene blue solution for 24 h., after that the teeth were sectioned longitudinally in mesiodistal direction and dye penetration in millimeters were measured in each cavity by using stereomicroscope. Data obtained were analyzed using ANOVA and LSD tests at 0.05 significance level.

Results: The microleakage of posterior packable composite (group-I) significantly (P<0.05) decreased by the two liners used (group-II and group-III), but there is no statistically significant differences (P>0.05) in enamel microleakage in respect to dye penetration were detected between the two liners used (group-II and group-III), with the association flowable composite Filtek flow (group-III) showing the best results.

Conclusion: The use of flowable composite (Filtek™ Flow) and resin modified glass ionomer (Vitrebond™ 7150) in the open sandwich technique decrease the microleakage of posterior packable composite (Filtek™ P-60) with margin located in enamel surface and better results with flowable composite.

Keywords: Flowable, microleakage, RMGIC and packable composite.

INTRODUCTION
Composite restorations have become a popular alternative to amalgam restorations in posterior teeth. Increase patient’s demand for better esthetic, possibility of mercury toxicity from amalgam and improvements in composite materials has significantly contributed the popularity of these materials. However posterior composite restorations have many clinical problems including: severe leakage, secondary caries, loss of anatomic form and high rate of wear. To overcome these short comings, Packable composites have been introduced to the dental market. The increased viscosity of these materials permits for greater packability with less slumping characteristics and lower polymerization shrinkage as compared to conventional universal composites.

Packable composites are indicated for stress bearing posterior restorations with improved handling properties.

Packable composites use amalgam techniques for placement and produce acceptable interproximal contacts and because of the high depth of cure and low polymerization shrinkage of packable composites, a bulk-filling technique may be possible.

Clinicians are concerned with poor adaptations of the material to tooth structure when placing posterior restorations. A materials ability to seal cavity preparations can be influenced by its composition, plastic deformation flow, coefficient of thermal expansion, modulus of elasticity and the mechanical stresses caused by cavity preparation and shape.

Composite resins have an initial polymerization shrinkage ranging from 1.67-5.68%. This shrinkage leads to the pulling of the
resin material from the walls of the preparations and results in a gap between the restoration and the tooth structure and causes microleakage.\(^{(3)}\)

Another factor affecting microleakage directly is the difference between the co-efficient of thermal expansion of the resin and the tooth structure. Temperature change also causes varying volumetric changes in the resin and tooth structure leading to marginal leakage.\(^{(4)}\) However concerns related to the ability of these stiffer materials to adequately adapt to internal areas and cavosurface margins have been raised. To offset this problem, materials with low viscosity and better adapt to the cavity used under packable composites.\(^{(1)}\)

So, the purpose of this an in vitro study was to evaluate the microleakage of posterior packable resin composite restorations with and without liner using open sandwich technique at the proximal box of class II preparation located above the cemento-enamel junction (in enamel).

**MATERIALS AND METHODS**

Twenty four caries-free recently extracted human upper premolars were selected for this study. The teeth were cleaned and stored in normal saline until sample preparation.\(^{(5,6)}\)

**Sample Preparation**

The teeth were sealed with a composite resin (Swiss Tec Composite, Coltene Whale dent) at the root apices and each tooth embedded in acrylic mould to hold the tooth during cavity preparation, restorative and testing procedures.\(^{(5)}\)

**Cavity Preparation**

In each tooth, standardized Class II cavities prepared as follow:

- **Occlusal Outline Form:** 2 mm in buccolingual width and 1.5 mm in depth measured from occlusal fissure to pulpal floor.
- **Proximal Boxes:** The depth of the proximal box from the proximal cavo-surface margin to the axial wall was 2 mm, so as the bucco-lingual width (2mm). The proximal box margin located 1 mm coronal to the CEJ (in enamel).\(^{(5)}\)

The cavity preparations were prepared by using high-speed hand piece with water spray and #1090 diamond fissure bur (Diatech Dental AG, Heerbrugg, Switzerland). The teeth were divided into three groups of 8 cavities each.

**Restorative Procedure**

**Etching**

Enamel and dentin were etched with Super etch gel (37% phosphoric acid, see Table-1 for composition and manufacture) for 15 sec., etching gel was applied to all of the prepared cavity wall approximately 0.5 mm beyond unprepared tooth surface using dispensing tips for application. Then the gel was removed with water spray for 10 sec.\(^{(7)}\)

**Bonding**

Immediately after blotting excess water, two coats with fully saturated brush tip of Adoper Single Bond 2 Adhesive (see Table-1 for composition and manufacture) was applied onto the etched tooth surface for 15 sec, with gentle agitation, then gently air dried for 5 sec. to evaporate solvents and light cured for 10 sec., according to manufacturer's instruction.\(^{(5)}\)

**Table 1: Materials used in the study: composition and manufacturers.**

<table>
<thead>
<tr>
<th>Material</th>
<th>Type</th>
<th>Composition</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filtek™ P-60</td>
<td>Packable composite</td>
<td>Resins: Bis-GMA, UDMA and Bis-EMA</td>
<td>3M ESPE, St. Paul, MN, USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fillers: Zirconia/silica - 61% by volume. The particle size range (0.01 – 3.5 µm)</td>
<td></td>
</tr>
<tr>
<td>Filtek™ Flow</td>
<td>Flowable composite</td>
<td>Resins: Bis-GMA and Bis-EMA</td>
<td>3M ESPE, St. Paul, MN, USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fillers: Zirconia/silica - 47% by volume. The particle size range (0.01 to 6.0 µm)</td>
<td></td>
</tr>
<tr>
<td>Vitrebond™ 7150</td>
<td>Resin modified glass ionomer cement</td>
<td>Powder: ion-leachable fluoroaluminosilicate glass powder</td>
<td>3M ESPE, St. Paul, MN, USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Liquid: modified polyacrylic acid</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>With pendant methacrylate group, HEMA, water and photo-initiator</td>
<td></td>
</tr>
<tr>
<td>Adoper single bond 2 adhesive</td>
<td>Water/ethanol solvent based adhesive</td>
<td>HEMA, ethanol, water, bis-GMA, functional copolymer of polyacrylic and polyitaconic acids</td>
<td>3M ESPE, St. Paul, MN, USA</td>
</tr>
<tr>
<td>Super etch gel</td>
<td>Total Etching</td>
<td>37% Phosphoric acid etchant gel</td>
<td>SDI, Australia</td>
</tr>
</tbody>
</table>

Restorative Dentistry
**Group-II (RMGIC):** Resin modified glass ionomer cement (Vitrebond™ 7150, see Table-1 for composition and manufacture) was placed in 0.5 mm thick layer in axial wall and gingival margin using open sandwich technique and light cured for 20 sec. (7)

**Group-III (Flowable):** Flowable composite (Filtek™ Flow, see Table-1 for composition and manufacture) was applied in 0.5 mm increment depth in axial wall and gingival margin using open sandwich technique and light cured for 20 sec. (2)

**Filling**

The matrix band was adjusted in the matrix retainer Ivory no. 8, then the retainer and the band were seated around the tooth which was held in the acrylic mold. (5) The cavities were filled with packable composite as a restorative material in bulk technique by using the plastic instrument and light cured for 20 sec. to restore the cavities. All materials were polymerized using a halogen light curing unit (Dentsply, United Electronic Co.). Finishing procedure was performed with a fine diamond bur (Diatech Dental AG, Heerbrugg, Switzerland), then polished with a graded series of Sof-Lex discs (3M ESPE, St. Paul, MN, USA). Care was taken to avoid polishing the cervical margin. (7)

**Testing procedure**

All teeth were stored in distilled water at 37°C for 24 hours using incubator (JRAD, China), then thermocycled for 1000 cycles, with baths held between 5°C and 55°C, a dwell time of 30 sec. The teeth were previously sealed with a composite resin at the root apices, and two coats of nail varnish were applied on the tooth within 1mm of the restoration margins. (5) The teeth were then immersed in a 1 % methylene blue solution (Gain land Chemical Company, UK) for 24 hours at room temperature. Subsequently they rinsed with tap water and dried at room temperature (7). All specimens were sectioned longitudinally in mesiodistal using a water-cooled; slow-speed diamond saw ISO 524 (Top Dent, Swiss Made). The lengths of the dye penetration in millimeters were examined with a stereomicroscope (40X magnifications, Hamilton, BioVision 320). (5)

**Statistical analysis** was performed with SPSS software package (version 19.0). Analysis of Variance test (ANOVA) and least significant difference (LSD) were performed to test for any significant difference between the groups in microleakage values. The mean difference is significant at the 0.05 level.

**RESULTS**

The mean and standard deviation of microleakage values are presented in (Table- 2) and (Figure- 1). The data showed that there is statistically significant difference (p<0.05) between all groups in microleakage values by using ANOVA test (Table- 3). When the mean values of microleakage of the groups compared by LSD test, the result showed that microleakage of posterior packable composite in control group (Group-I) significantly decrease by using of RMGIC (Group-II) or flowable composite (Group-III) as a lining, and the higher reduction was in group-III, but there was no statistical significant difference (P>0.05) between group-II and III in microleakage reduction (Table- 4).

**DISCUSSION**

Packable composites most commonly used as posterior restorative materials, however, disadvantages like polymerization shrinkage, high co-efficient of thermal expansion and increased wear, limited their use. Further research led to improvements in wear resistance and strength but the problem of polymerization shrinkage remained.

Polymerization shrinkage resulted due to the contraction of the resin during curing and is in the range of 1.67-5.68%. This polymerization shrinkage results in the formation of a marginal gap which can ultimately lead to increased microleakage, (8) so various techniques and modifications in the material were proposed to overcome and minimize polymerization shrinkage and microleakage. These included changes in filler content, use of expanding resin matrices and modifications in curing techniques like soft curing, ramped curing and delayed curing. (9) They observed that when the material is
in more rigid state, most of the polymerization cannot be observed and is transmitted to the adhesive interface. Here, the contraction stress can become responsible for opening marginal gap. It has been proposed that an “elastic” layer at the restoration base be incorporated to act as a stress absorber, not only of the functional loads but also of the internal tensions induced by composite polymerization.\(^{(8,10)}\)

In our study, the concept of using various liners as stress absorbing cushions to minimize polymerization shrinkage was proposed; two types of materials (resin modified glass ionomer cement and flowable composites) were experimented as stress absorbing liners. The use of GIC as lining material in conventional sandwich restoration reduces considerably the of GIC as lining material in conventional experimented as stress absorbing liners. The use of GIC as lining material in conventional sandwich restoration reduces considerably the polymerization shrinkage of the composite resin used, thus the amount of polymerization shrinkage of the composite resin is decreased and the marginal adaptation may be improved. A further advantage of the sandwich technique is the fluoride-release property of GICs, which is considered to have some inhibitory effect on caries formation and progression around the restoration. The sandwich restorations using RMGIC showed significantly less dye penetration than control group (packable composite without lining), this result in agreement with the results of Chuang et al.\(^{(6)}\) and Donly et al.\(^{(11)}\). RMGIC obtained by adding a resin, usually the water-soluble polymerizable 2-hydroxyethyl methacrylate (HEMA), to the liquid and its bonding process to tooth structure takes place by micromechanical retention, like in resin composites. The setting reaction of RMGIC follows two distinct mechanisms: resin polymerization and acid-base reaction. The better sealing produced by RMGIC is a result of the formation of resin tags into the dentinal tubules allied to the ion exchange process present in the interface between dentin and RMGIC, this assumption stands to be the reason for the superior performance of the RMGIC. In addition, the presence of HEMA in the RMGIC is responsible for the increased bond strengths to resin composite and prevent dye penetration through the interface of these materials, as demonstrated by the results of the present study.

The shrinkage stresses of resin composites during polymerization create forces that compete with the adhesive bond, and this may disrupt the bond to cavity walls, which is one of the main causes of marginal failure and, subsequent, microleakage. The main rationale behind the use of flowable composites is the formation of an elastic layer that may compensate for the polymerization shrinkage stresses.\(^{(5)}\) The third group in this study showed that using of flowable composite as liner under packable composite significantly reduced microleakage more than RMGIC, this result due to low filler loading of flowable composite (47% by volume) that enhanced flow and reduced elastic modulus. These two characteristics reduce microleakage by increasing adaptation and forming an elastic stress-absorbing layer.\(^{(8)}\) These results in agreement with studies by, L ee vail o j et al.\(^{(11)}\), Peutzfeldt and Asmussen\(^{(8)}\) and Stefanski and van Dijken.\(^{(12)}\)

The reduction in microleakage values by using two types of liners, measured when the margin of class II cavity located at enamel surface. Enamel has homogeneous structure, hydrophobic character and strong adhesion achieved with its inorganic tissue.\(^{(13)}\) In the future, further clinical studies and researches needed to compare between these two liners at margin located in dentin surface.

CONCLUSIONS

Under the conditions of this an in vitro study:

- None of groups tested were able to totally prevented microleakage at enamel margin.
- Microleakage of packable composite significantly decreases by using of RMGIC and flowable composite as lining.
- Microleakage of flowable composite with margin located at enamel surface less than resin modified glass ionomer in open sandwich technique.
- There were no significant differences between two liners tested in term of microleakage.

REFERENCES

6. Chuang SF, Lin YT, Lin TS, Chang CH, Garcia-Godoy F. Effects of lining material on microleakage and internal voids of class II resin-

Table 2: Descriptive Analysis: Mean, Standard deviation of microleakage values of the groups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Means</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group-I (Control)</td>
<td>8</td>
<td>0.78</td>
<td>0.124</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td>Group-II (RMGIC)</td>
<td>8</td>
<td>0.63</td>
<td>0.106</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Group-III (Flowable)</td>
<td>8</td>
<td>0.55</td>
<td>0.119</td>
<td>0.4</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Table 3: One Way- ANOVA Test for all groups

<table>
<thead>
<tr>
<th>Sum of Squares</th>
<th>D.f</th>
<th>Mean Squares</th>
<th>F</th>
<th>P-Value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>0.231</td>
<td>2</td>
<td>0.115</td>
<td>8.43</td>
<td>0.002</td>
</tr>
<tr>
<td>Within Groups</td>
<td>0.287</td>
<td>21</td>
<td>0.014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.518</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: LSD test compare between the groups in microleakage values (mm)

<table>
<thead>
<tr>
<th>Groups</th>
<th>P-value</th>
<th>Level of significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>I vs. II</td>
<td>0.018</td>
<td>S</td>
</tr>
<tr>
<td>I vs. III</td>
<td>0.001</td>
<td>S</td>
</tr>
<tr>
<td>II vs. III</td>
<td>0.150</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS: non- significant, S: significant