A Comparative Evaluation of Microleakage in Class V Composite Restorations using a Fifth Generation Adhesive and a Glass Ionomer Bonding Agent - An In Vitro Dye Leakage Study

Dipali Shah

Abstract
Objectives: The dawn of minimally invasive dentistry has led to the development of materials which rely on the use of effective adhesion to remaining tooth tissue. Despite making important advances, dentin bonding has to overcome hurdles with respect to structural heterogeneity of dentin and long term stability of the bond. The primary mode of failure for adhesive restorations has been described as the loss of marginal adaptation and loss of retention. Methods: This in vitro study was undertaken to assess marginal adaptation and microleakage of Class V lesions using two cavity designs, a fifth generation dentin adhesive and a glass ionomer bonding agent-liner in extracted human molars, restored with composite resin restorations. Extracted permanent molars were divided into four groups (n=10). Class V cavities on buccal surfaces with retentive or non retentive features were prepared. A comparative dye leakage study was done between Syntac single component and Fujibond LC bonding agent, when cavities were restored with Heliomolar composite resin. 2% methylene blue dye was used to assess microleakage under stereomicroscope. The scores obtained were subjected to the Kruskal Wallis one-way analysis and Mann Whitney U test. Results: Results of this study showed that the glass ionomer bonding agent-liner groups in both retentive and non-retentive cavities exhibited statistically significant (P<0.05) less microleakage as compared to the non-retentive dentin bonding agent group on the dentinal/cemental cavosurface margins. Conclusion: Within the limits of the study, it was concluded that the glass ionomer bonding agent-liner may be effective in reducing gingival microleakage in Class V situations with gingival margins in cementum and dentin.

Key words: Dentin bonding agent, Glass ionomer liner, Microleakage, Class V cavity, Retention groove

Introduction
The evolution of restorative materials has seen the dentist's repertoire shift towards composite resin restorative materials which are dependent on reliable adhesive bonding. Enamel and dentin present separate challenges to bonding. A breakthrough in dentin bonding with adhesive resins was achieved by Nakabayashi by creation of resin infiltrated hybrid layer in the dentin. Simultaneous to the development of resin based dentin bonding agents (DBA), the glass ionomer cement have undergone changes in their formulations and clinical applications. Light cured glass ionomer bonding agent-liner has been introduced for direct bonding to dentin for resin composite restorations. Whether these bonding systems and glass ionomer bonding agent-liner ensure adequate marginal adaptation of composite resins to tooth structure remains to be assessed.

Non-carious Class V restorations are deemed to be the true test of adhesive-mechanic performance as no macro-mechanical retention is available and the restoration margins exist in both dentin and enamel. When polymerized the composite resin shrinks towards the superior bond at the occlusal margin in enamel and away from the weaker bond at the gingival margins in dentin/ cementum creating a cervical gap with potential for microleakage. The present in vitro study was undertaken to compare and evaluate the microleakage pattern around Class V composite resin restorations bonded with a fifth generation dentin adhesive and a glass ionomer bonding-agent liner utilizing two different cavity designs.

Materials and Methods
Forty freshly extracted, intact and non carious human permanent molars were selected for the study. The teeth were cleaned ultrasonically, washed and stored in distilled water to prevent dehydration. Nonretentive, V-shaped cavities similar to abrasion defects were prepared on the buccal surface of twenty teeth with tapered diamond point using high speed. Each cavity had specific dimensions namely- 1.5 mm in depth, 4 mm in mesiodistal width and 3 mm occluso-gingival height such that the gingival margin was 1mm below cement-enamel junction of the tooth. A bevel was placed at an angle of 45° at the enamel margin with a 1 mm width.

Retentive, box shaped cavities were prepared on the buccal surface of twenty teeth with tapered diamond point using high speed. Each cavity had specific dimensions namely- 1.5 mm in depth, 4 mm in mesiodistal width and 3 mm occluso-gingival height such that the gingival margin was 1mm below cement-enamel junction of the tooth. A bevel was placed at an angle of 45° at the enamel margin with a 1 mm width. Additionally, a retentive groove was placed along the full length of the axiogingival line angle with a no. ¼ round carbide bur at the expense of the gingival wall.
Grouping
The cavities were divided into four groups and restored using light cured composite resin in two increments after using one of the bonding systems as dentin adhesives. All the samples were prepared and restored by a single operator. The intensity of light curing unit (visible light curing unit EMS) was checked periodically by the inbuilt radiometer.

Group I: 10 teeth with retentive Class V cavities were restored using Syntac single component bonding system and Heliomolar composite resin.

Group II: 10 teeth with non retentive Class V cavities were restored using Syntac single component bonding system and Heliomolar composite resin.

Group III: 10 teeth with retentive Class V cavities were restored using Fujibond LC bonding agent-liner and Heliomolar composite resin.

Group IV: 10 teeth with non retentive Class V cavities were restored using Fujibond LC bonding agent-liner and Heliomolar composite resin.

The materials used in this study are shown in Table 1.

Table 1: The materials used in this study

<table>
<thead>
<tr>
<th>Product name</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-mail preparator GS - (Vivadent Ets)</td>
<td>Enamel and dentin Conditioner</td>
</tr>
<tr>
<td>Fuji Bond LC Light cured resin - (GC Corporation, Tokyo, Japan)</td>
<td>Light cured resin- reinforced glass ionomer dentin/ enamel bonding agent-liner</td>
</tr>
<tr>
<td>GC cavity conditioner (GC Corporation, Tokyo, Japan)</td>
<td>Cavity conditioning liquid</td>
</tr>
<tr>
<td>Heliomolar (Vivadent Ets)</td>
<td>Microfilled, radiopaque light cured composite resin</td>
</tr>
</tbody>
</table>

Restorative Procedure
A. Using dentin bonding system: A total etch technique using 37% phosphoric acid for complete cavity for 15 seconds was used. Later the cavity was thoroughly rinsed with water and gently air dried with chip syringe, keeping dentin surface glistening for wet bonding technique. The dentin bonding system was applied following manufacturer's instructions and light cured for 20 seconds. The cavities were restored with Heliomolar composite resin used in two increments, curing each increment for sixty seconds.

B. Using Glass ionomer liner: The cavities were conditioned with GC cavity conditioner for 10 seconds, rinsed with water and air dried keeping the dentin surface glistening. The powder and liquid were mixed and applied as per manufacturer's instructions (P: L=0.7:1) to the conditioned surface. Later this was light cured for 20 seconds followed by restoring the cavities with composite resin in two increments.

The composite restorations were finished and polished using composite finishing and polishing points and disks (Sof-Lex, 3M) under water spray. The teeth were stored in distilled water for 24 hours. Teeth of each group were thermocycled for 500 cycles between 4± 5° C and 55±5°C with a dwelling time of 1 minute at room temperature. The apical foramen of the thermocycled teeth were sealed with sticky wax to ensure no dye leakage occurred from the apical foramen. Later, the thermocycled teeth were coated with two layers of resin varnish within 1mm of the restorations to limit dye penetration to the margins of the restoration. The samples were placed in 2% aqueous methylene blue dye for 48 hours and later thoroughly rinsed with water to remove excess dye.

Samples were later sectioned longitudinally through the center of the tooth in a bucco-lingual direction with a diamond disk under copious water spray. The extent of dye penetration was qualitatively evaluated using stereomicroscope under 20X magnification using the following scoring pattern.

Criteria for evaluation
The occlusal and gingival margins were evaluated separately and scored for dye penetration as per the scale shown in Fig.1 & Fig.2.

Fig.1: Non-retentive cavity margins
Score 0 = No evidence of dye penetration
Score 1 = Dye penetration along the interface to ≤½ the depth of cavity.
Score 2 = Dye penetration to full depth of cavity.
Score 3 = Dye penetration to the base of the cavity and beyond.
Fig. 2: Retentive cavity margins
Score 0 = No penetration
Score 1 = Dye penetration ≤ half the distance from the cavosurface to the margin to the axial wall.
Score 2 = Dye penetration more than half the distance from the cavosurface to the axial wall but not including the axial wall.
Score 3 = Leakage to or beyond the axial wall.

Table 2: Scoring at the gingival margins

<table>
<thead>
<tr>
<th>Groups</th>
<th>Grade-0</th>
<th>Grade-1</th>
<th>Grade-2</th>
<th>Grade-3</th>
<th>Total No. of specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>II</td>
<td>-</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>III</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>IV</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>-</td>
<td>10</td>
</tr>
</tbody>
</table>

Results
In this study, there was almost total absence of microleakage at occlusal margins of all the groups assessed but gingival margins of all group showed leakage. Hence the gingival leakage scores were subjected to statistical analysis. The results of this test were tabulated (Table 4 and 5). A graphical representation of gingival scores in all groups is presented in Graph 1.

Table 2: Scoring at the gingival margins

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1.5</td>
<td>0.85</td>
</tr>
<tr>
<td>II</td>
<td>2.0</td>
<td>0.82</td>
</tr>
<tr>
<td>III</td>
<td>0.5</td>
<td>0.72</td>
</tr>
<tr>
<td>IV</td>
<td>0.9</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Table 3: Mean Scores and Standard Deviation

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Rank</th>
<th>Chi-Square Value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>24.15</td>
<td>15.47</td>
<td>0.0015*</td>
</tr>
<tr>
<td>II</td>
<td>29.55</td>
<td>15.47</td>
<td>0.0015*</td>
</tr>
<tr>
<td>III</td>
<td>11.55</td>
<td>15.47</td>
<td>0.0015*</td>
</tr>
<tr>
<td>IV</td>
<td>16.75</td>
<td>15.47</td>
<td>0.0015*</td>
</tr>
</tbody>
</table>

* -value of 0.0015 indicated that there is significant difference among at least two groups. Hence the Mann-Whitney U test was employed to identify the differences using Bonferroni method of adjustments for multiple comparisons.

Table 4: Results of Kruskal Wallis Test

The following observations were made from the statistical calculations:

1. All the groups provided an almost complete seal at the occlusal margins of the Class V composite resin restorations.
2. The gingival margins of all groups exhibited microleakage irrespective of the cavity design and the bonding agents used.

Table 5: Results of Mann–Whitney U-Tests

<table>
<thead>
<tr>
<th>Groups compared</th>
<th>Calculated value of U</th>
<th>Calculated value of W</th>
<th>Standard normal deviate Z</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Vs II</td>
<td>34.5</td>
<td>89.5</td>
<td>-1.2439</td>
<td>1.0000</td>
</tr>
<tr>
<td>I Vs III</td>
<td>19.0</td>
<td>136.0</td>
<td>-2.4691</td>
<td>0.081</td>
</tr>
<tr>
<td>I Vs IV</td>
<td>29.0</td>
<td>126.0</td>
<td>-1.7568</td>
<td>0.474</td>
</tr>
<tr>
<td>II Vs III</td>
<td>9.5</td>
<td>145.5</td>
<td>-3.1758</td>
<td>0.009*</td>
</tr>
<tr>
<td>II Vs IV</td>
<td>15.5</td>
<td>139.5</td>
<td>-2.8169</td>
<td>0.0288*</td>
</tr>
<tr>
<td>III Vs IV</td>
<td>32.0</td>
<td>87.0</td>
<td>-1.51</td>
<td>0.7866</td>
</tr>
</tbody>
</table>

*p- Values are adjusted for multiple comparisons by Bonferroni method. *p -values < 0.05 statistically significant values
3. At the gingival margins Group I (retentive-DBA) exhibited a mean microleakage score of 1.5 while, Group II (non-retentive-DBA) exhibited maximum microleakage with a mean score of 2. Group III (retentive-GI) exhibited minimum microleakage with a mean score of 0.5. 60% of the restorations, exhibited no microleakage in this group while group IV (non-retentive-GI) exhibited slightly more microleakage than group III with a mean score of 0.9.  

4. The mean score for Group I was less than that of group II. Mean score for group III was less than that of Group IV. Thus the retentive cavity designs exhibited lesser microleakage scores than the non retentive cavity designs for each bonding system though the difference was not statistically significant.  

5. When comparing group III with group II the difference was statistically significant (P<0.05). Also the difference between group IV and group II was statistically significant (P<0.05). 

Thus Fuji Bond LC bonded restorations in both the cavity designs gave statistically significant better performance than the Syntac Single Component bonded restorations in non-retentive cavity designs.

Discussion

Microleakage has been associated with the ability of bacteria, toxins and fluids to penetrate at the tooth restoration interface. Study of microleakage performance of materials in simulated cavities contributes to a better assessment of the recently introduced materials before they are routinely used in clinical situations. Generally when new bonding systems are introduced, studies tend to focus on bond strengths of the materials which are obtained on flat enamel and dentin surfaces. The actual performance of the bonding system in a three dimensional cavity is often neglected. Hence in this study the marginal sealing ability of two recent bonding systems was assessed simulating Class V cavity situations in extracted teeth.

The dye penetration method was chosen for the present study as it is a simple and frequently used method for assessing microleakage which has been used by many investigators. 2% methylene blue dye was preferred to radioisotopes and silver nitrate. Although this method has its short comings such as being qualitative and requiring sectioning of teeth, it does not require authorization and cautious handling as in the case of radioisotopes. Also studies using GIC report higher leakage scores as GIC tends to absorb the radioisotope.

In this study there was almost no microleakage at the enamel margins of the restorations bonded with Fuji Bond LC and Syntac single component in both retentive and non-retentive cavities but leakage occurred at gingival margins which is in confirmation with other studies.

The enamel margins were bevelled in all the cavities which resulted in an increased surface area of etched enamel and better bond strengths. This also eliminated the need for groove retention thus helping in conservation of tooth structure.

The microleakage observed at the gingival margins may be attributed to the polymerization shrinkage of the composite resin towards the side of the strongest bond i.e. the composite restoration shrinks towards enamel causing leakage to occur at the less strongly bonded dentinal and cemental margins caused by polymerization contraction stresses.

Though the resin based adhesives may claim of higher bond strengths than the glass ionomers, the glass ionomers have a linear coefficient of thermal expansion similar to that of tooth structure (12 ppm/C). Hence even after the thermocycling regimen, microleakage of the glass ionomer bonded restorations remained minimal while Syntac single component bonded restorations showed more dye penetration. This was in confirmation with a study by Yap et al. which showed no significant difference in microleakage scores of restorations using Fuji Bond LC and other single component adhesives before thermocycling. However, after thermocycling there was a significant difference in microleakage scores such that the glass ionomer bonded restorations using Fuji Bond LC exhibited significantly lesser microleakage than the other single component resin based adhesives. The intrinsic porosity of glass ionomer provides them with a free, space so that this space can expand in presence of moisture. Some compensation for the polymerization shrinkage may come from water sorption which leads to swelling of the glass ionomer base-liner. In particular, the light curing versions of the glass ionomer show an early and substantial volume gain from water uptake thus compensating for polymerization shrinkage of composite resin.

A 2-step etch-and-rinse (5th generation adhesive) was used as these systems have shown comparable stability in bonding as compared to the self etch systems which noted reduced bond strengths in longevity outcome data.

In the present study, a microfilled composite resin was used to restore the Class V cavities, as the Young’s modulus of elasticity of these composites is lower than that of the hybrid composites. It has been shown that lower the Young’s modulus of the restorative material the less is the risk of
debonding due to polymerization shrinkage stress. In addition the highly filled hybrid composites cannot flex adequately when subjected to flexural forces and may transfer stress to the bonding interface.

From the results of this study, a positive correlation was found between glassionomer liner-adhesive and composite resin restoration for successful marginal adaptation at gingival margins. Further investigations using different bonding systems, artificial ageing, degradation by enzymes can throw more light on longevity of bond between glass ionomer liner-adhesives and composite resin restorations.

Conclusion
From the foregoing analysis and discussion it is evident that the glass ionomer bonding agent-liner, Fuji-Bond LC exhibited lesser microleakage than Syntac single component adhesive. In this comparative study, the retentive cavity designs showed lesser leakage than the nonretentive cavity designs for each bonding system used though the results were not statistically significant. In addition to minimal leakage observed with glass ionomer bonding agent-liner, the benefit of fluoride release from the restoration margins would provide an anticariogenic effect to the surrounding tooth surface.

Although, it may not be entirely accurate to equate results of this in-vitro study with the in-vivo performance and durability of these bonding systems it does give an indication of the likely clinical performance of these bonding systems.

References

Source of Support: Nil.
Conflict of Interest: None Declared.