Microleakage of three different materials in cervical restorations with different cavity margin locations: a comparative in vitro study

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The main objective of tooth restoration is the protection of exposed dentine against microbes and their toxins. The interface between the restoration and dental hard tissue is an area of clinical concern as insufficient sealing can result in some dental pathology. Microleakage may be the clinically undetectable passage of the microbes, fluids, molecules between a cavity wall and the restorative material. This study aimed to evaluate the sealing ability of flowable composite, light cured (resin reinforced/modified) glass ionomer and chemically cured glass ionomer cement in class V cavities at enamel and cementum margins. Thirty extracted premolars were divided into three groups, according to the restorative materials used. Class V cavities were prepared on the buccal and lingual surface of each premolar exhibiting enamel margin at the occlusal surface and cementum margin at the cervical surface. Then, each group was subdivided into thermocycled and not thermocycled subgroups. The teeth were water sealed, immersed in methylene blue solution for 12 hours. The samples were cut buccolingually and the degree of dye penetration was assessed with the aid of stereomicroscope. A chi square showed significant differences in microleakage between the restorative materials for enamel walls in both thermocycled (P<0.05) and not thermocycled subgroups (P=0.000). The worst dye penetration score was associated with resin reinforces glass ionomer while the smallest penetration score was associated with flowable composite. Also the results showed greater microleakage scores in cementum margins than the enamel margins with a significant statistical value for all groups (P=0.0001). There was no significant difference in leakage between thermocycled and not thermocycled groups (P > 0.05). In conclusion; none of the three restorative materials completely sealed the tooth/restoration interface at occlusal and gingival margins. However; other studies should be done for further evaluation of the clinical performance of the three restorative materials.

Key words: Microleakage, class V cavity, flowable composite, Light cured (resin modified/reinforced) glass ionomer cement, chemically cured glass ionomer cement.

INTRODUCTION

The incidence of Non-carious lesions in cervical tooth surface is increasing due to augmentations of lifespan and tooth retention period. The number and size of lesions both tend to increase with age. Commonly they are found on the facial aspects of the teeth and their prevalence and distribution can depend on the oral hygiene habits, as well as the right or left handedness of the patient when tooth brushing. The loss of dental hard tissue in the cervical region appears to be a multi-factorial phenomenon (Wood et al., 2008).

Cervical lesions can be caused by incorrect tooth brushing, caries or occlusal loading factors. Human teeth with cervical lesions usually have little or no enamel at the cervical margin, therefore restorative materials come into contact with cementum or dentine, microleakage is critical at the margins of cervical lesions because of the
lack of enamel. Since microleakage is a major drawback of filling materials when restoring cervical lesions, the marginal sealing ability of these materials must be considered at the time of restorative treatment (Xie et al., 2008; Jang et al., 2001).

A variety of in vitro methods have been introduced into the study of microleakage including compressed air, neutron activation, electrochemical, fluid filtration, bacteria and use of dyes (Taylor and Lynch, 1992; Karagenc and Cansever, 2006).

The most effective method for evaluating the sealing ability of restorative materials to cavity walls is by microleakage studies that use color dye agent or chemical tracers which are able penetrate into and stain the tooth/restoration interface (Hilton, 2002).

Dye penetration tests are usually used because they are generally simple, fast and reproducible methods (Heintze, 2007; Naghma et al., 2009; Srikumar et al., 2012).

The restorative materials to be used in the study were:flowable composite:Light cured (resin modified/reinforced) glass ionomer cement, chemically cured glass.

Since the introduction of glass ionomer cement (GIC) in 1972, they have been widely used as restorative materials, luting cements and base. These materials have widened the armamentarium of tooth-colored restorative materials, and in particular, they have been successfully used for restoration of cervical lesions. Their main advantages are relative ease of use, bonding potential to enamel and dentin, and fluoride ion release.

Among the disadvantages are sensitivity to desiccation and moisture contact during the early setting stage. GICs are alternative materials to composites for the cervical lesions because of their chemical adhesion to tooth structure, fluoride release, biocompatibility, low shrinkage values, reducing microleakage, and acceptable aesthetics (Sunil et al., 2012).

GICs are clinically attractive dental materials that have certain unique properties that make them useful as restorative and luting materials. This includes adhesion to moist tooth structures and base metals, anticariogenic properties due to release of fluoride, thermal compatibility with tooth enamel, biocompatibility and low toxicity. On the other hand, poor mechanical properties limit their extensive use in dentistry as a filling material in stress-bearing areas (Xie and Brantley, 2000).

Light-cured (resin modified) GIC were introduced to overcome the problems of moisture sensitivity and low early mechanical strengths associated with the conventional GIC, which contain hydroxyethylmethacrylate (HEMA) or bisphenol-glycidyl methacrylate (BIS-GMA) (Sunil et al., 2012).

The resin content of light-cured GICs, which varies among available products, produces microleakage shrinkage, which could cause an adverse effect on marginal adaptation (Behjatolmoluk et al., 2007).

Composite resins are polymer matrix filled, tooth-colored restoratives that derive their physical properties and handling characteristics from loading with reinforcing filler particles and the viscosity of the resin matrix. Composite resins can be classified by filler size and percent filler loading, as well as by the viscosity of the composite. Most direct restorative composite resins have a putty-like consistency (Moon et al., 2002).

The flowable composites have a lower percentage of inorganic fillers, and therefore a higher percentage of matrix than traditional hybrid composites providing high fluidity (Kasraie et al. 2012).

Cervical lesions are very often caused by incorrect tooth brushing and dental caries, and usually have little or no enamel at the cervical margin (Litonjua et al., 2003). Flowable composite resins are widely used in clinical practice and are the most common resin materials that recommend for restoring these lesions instead of conventional resin composites.

These material have good aesthetic properties, and because of flow viscosity, are easier to place and more self-adaptable compared to stiffer restorative materials (Miyasaka and Okamura, 2009; Kleverlaan and Feilzer, 2005; Yazici et al. 2008; Qin and Liu, 2005; Mostafa, 2012)

MATERIALS AND METHODS

In the present study the flowable composite, shade A2 (light cured, low viscosity flowable composite syringe, Wave,SDI, Australia), resin reinforced GIC, shade A2 (Riva light cure assorted capsule, SDI, Australia), chemically cured condensable GIC, shade A2(Rivaseal cure assorted capsule, SDI, Australia) were used for cervical restorations. Etching gel (37% phosphoric acid, Variolineer, Switzerland), single-component Dentin/Enameladhesive system (Stae, SDI, Australia), Riva conditioner (SDI, Australia) and Riva coat (SDI, Australia) were also used in the present study.

Thirty fresh human premolars without decay, cracks or previous restorations extracted for orthodontic purposes were selected. Then they were thoroughly cleaned, and stored in physiological saline solution at room temperature for less than 3 months before use. The teeth were scaled with a scalpel and/or scaling instruments to remove residual tissues and calculus. They were polished with rubber cup and pumice and then rinsed thoroughly with tap water.

On the lower third of the buccal and lingual surfaces of each tooth, a round shaped Class V cavity was prepared with a high speed hand piece under water cooling using a tungsten carbide fissure bur (No. 330L, USA).

The cavities were located on the cementum-enamel junction, half in enamel and half in occlusal (enamel)
cavosurface margins were beveled to approximately 45° and the gingival (cementum) cavosurface margins were left at 90°. The bur was changed with a new one after each five cavity preparations.

The cavities were approximately 3 mm in diameter and 2 mm in depth (Ammar, 2009). A digital caliper (Mitutoyo, USA) was used to measure the cavity dimensions. The length of the bur was used as a guide for the cavity depth.

The specimens were randomly divided into three groups of 10 teeth (each group with 20 cavities), according to the materials used to restore the cavity which are: group 1 (Flowable composite), group 2 (light-cured GIC) and group 3 (Chemically cured GIC).

For the cavities of group 1, the total-etch technique was used on enamel and cementum with 37% phosphoric acid for 20 seconds. The acid was applied initially to the enamel margins and then extended from the superficial to deep dentin. After application of the acid gel, the substrate was washed with an air/water spray for 20 seconds and excess humidity was removed by an absorbent paper applied on the dentin.

The enamel and dentin were saturated with a generous amount of bonding agent using a Viva-dent applicator for 10 seconds. Flowable composite inserted with the needle provided by the manufacturer into the preparations in one increment and adaptation of the composite material was done by a celluloid strip, curing of composite was done for 20 seconds.

The cavities of group 2 and group 3 are conditioned with Riva conditioner for 10 seconds according to the manufacturer's instruction, and then rinsed with water. After that the excess water was removed by application of an absorbent paper on the dentin. Then the group 2 cavities were filled with Riva light cure and light cured for 20 seconds. While the cavities of group 3 were filled with Riva self-cure. After two minutes, the Riva coat was applied to the restoration surfaces and light cured for 20 seconds.

Following filling of the cavities of all three groups, the restorations were polished with a polishing bur (Harmonic, RD144, China).

After that the teeth of each group were also subdivided into two subgroups of 5 teeth (10 cavities), one subgroup without thermocycling and the other was thermocycled at 200 cycles between 5 and 55°C ± 2°C with a dwell time of 60 seconds (FaHAD et al., 2011). The teeth were dried and sealed with two layers of nail polish on all external surfaces, leaving a 1 mm wide varnish-free margin around the restoration.

All specimens were immersed in 2% methylene blue solution at room temperature for 12 hours and then rinsed in running water. Following that, all the samples were sectioned buccolingually through the center of the restorations with a slow-speed diamond disc (Suzhou-Syndent, China), at low-speed under liquid cooling as shown in (Figure 1A).

The dye penetration depth along the cavity wall (including both enamel and cementum walls) was measured with a stereomicroscope (Olympus) at a magnification of X40 magnification by two examiners, as shown in (Figure 1B). The depth of dye penetration was analyzed according to a 0-3 scale scoring system as suggested by Silveira de Araujo (Sunil et al., 2012; Silveira et al., 2006). Score 0 = No evidence of dye penetration

Score 1 = Dye penetration along the occlusal/gingival wall to less than half of the cavity depth
Score 2 = Dye penetration along the occlusal/gingival wall to more than half of the cavity depth, but not extending on to the axial wall
Score 3 = Dye penetration along the occlusal/gingival wall to the full cavity depth and extending on to the axial wall.

RESULT

The statistical analysis showed that the Chi-square test had a significant association between the penetration scores and the three restorative materials for enamel walls in both thermocycled (P<0.05) and not thermocycled subgroups (P=0.000), the worst dye penetration score was associated with group 2 (resin reinforces GIC) while the smallest penetration score was associated with group 1 (flowable composite). But there was no significant association found between dye penetration scores and the three groups for cementum walls in both thermocycled and not thermocycled subgroups (P> 0.05). All these findings were showed in Table 1.

Also chi-square test presented a significant association (P= 0.0001) between the microleakage scores and the cavity walls (enamel and cementum), the greater leakage scores was associated with cementum walls. But there was no significant relation found between the penetration scores and thermocycling (P> 0.05) as showed in Table 2 and Table 3.

DISCUSSION

One of the major objectives of tooth restoration is the protection of exposed dentine against bacteria and their toxins. The interface between the restoration and dental hard tissue is an area of clinical concern as insufficient sealing can result in marginal discoloration, secondary caries, and pulpitis. For that reason, adequate sealing is essential for optimal clinical performance.

Microleakage may be defined as the clinically undetectable passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative material. Clinically, microleakage can lead to staining around the margins of restorations, postoperative sensitivity,
secondary caries, restoration failure, pulpal pathology or pulpal death, partial or total loss of restoration (Wood et al., 2008; Kasraie et al., 2012; Ammar, 2009; Anthony and Daniel, 1991; Siavash et al., 2012).

A large variety of methods have been described to compare the sealing efficiency of restorative systems. In the present study, linear dye penetration method was used and the dye utilized dye was 2% methylene blue.

In the present study, there was a significant association between the microleakage in the occlusal margins (enamel walls) and the filling materials used for restoration of class V cavities in thermocycled groups (P=0.011) and not thermocycled groups (P=0.000). The materials, by their sequences of the dye penetration scores from lowest to highest scores, were: flowable composite, chemically cured GIC and resin reinforced GIC.

The smallest degrees of microleakage in the occlusal margins were observed in flowable composite. This result agrees with the result of other studies (Xie et al., 2000; Prabhakar et al., 2003). The reason for this result can be related to the low viscosity, handling characteristics and delivery system of flowable composites which offer higher, better cavity adaptation to the internal cavity wall (Naghma et al., 2009), and strong dentine bond like results. Another reason is that flowable composite has low modulus of elasticity and increased flexibility, believed to ameliorate the stresses of polymerization shrinkage and better preserves the integrity of the bond to tooth structure (Prabhakar et al., 2003).

Microleakage of resin reinforced/modified GIC in occlusal margins was more than self-cure GIC. This outcome in agreement with the study done by Chwang et al. (2000). This can be related to that the initial light cure irradiation seemed to greatly reduce the acid base reaction during the early setting stages of resin modified GIC. Other studies have pointed out that significant dimensional changes and surface hardening can occur after initial light curing of the resin component of resin modified GIC and further contraction continue for the first 24 hours as the material matures (Naghma et al., 2009).

This result disagrees the results of other studies done by Kanika et al. (2011) exhibiting that resin-modified glass ionomer cements displayed less leakage than self-cured glass ionomer and the study by Nakanuma et al. (1998) in which: resin-modified GIC showed higher...
This table shows the effect of the flowable composite, light cured GIC and chemically cured GIC on the dye penetration scores in both enamel and cementum walls, in thermocycled and not thermocycled groups.

Table 1. Effect of restorative materials on the dye penetration scores

<table>
<thead>
<tr>
<th>Cavity walls</th>
<th>Thermocycled</th>
<th>No Thermocycling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>Flowable composite</td>
<td>Light cured GIC</td>
</tr>
<tr>
<td>Score 0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Score 1</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Score 2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Score 3</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

This table shows the effect of the flowable composite, light cured GIC and chemically cured GIC on the dye penetration scores in both enamel and cementum walls, in thermocycled and not thermocycled groups.

Table 2. Comparison of scores of microleakage between enamel and cementum walls

<table>
<thead>
<tr>
<th>Degree of dye penetration</th>
<th>Enamel</th>
<th>Cementum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score 0</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Score 1</td>
<td>32</td>
<td>15</td>
</tr>
<tr>
<td>Score 2</td>
<td>8</td>
<td>23</td>
</tr>
<tr>
<td>Score 3</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>

For each score of microleakage (0-1), there are numbers of the dye penetration readings of the samples along the tooth restoration interface in enamel walls and cementum walls. The scores of microleakage (0-3) are described in methodology.

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The adhesiveness to dentin than conventional GICs. Although the same differences in microleakage were found between the three materials in the gingival margins, but these differences are not significant statistically (P>0.05). This may be due to the absence of enamel and the cervical cavity margins were located in both dentine and / or cementum (Xie et al., 2008; Jang et al., 2001).
Table 3. Comparison of scores of microleakage between thermocycling and no thermocycling groups

<table>
<thead>
<tr>
<th>Degree of dye penetration</th>
<th>Thermocycled No.</th>
<th>No Thermocycling No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score 0</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Score 1</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td>Score 2</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>Score 3</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>

All specimens (No. = 120) are divided into thermocycled (No. = 60) and non thermocycled (No. = 60) groups. For each score of microleakage (0-3), there are numbers of the dye penetration readings of the samples along the tooth restoration interface for the two groups.

The scores of microleakage (0-3) are described in methodology. 

\[ X^2(3, n=120) = 5.674, \ p = .1286 \]

In the current study, the cementum walls (gingival margins) showed higher microleakage than the enamel walls (occlusal margins) with a significant statistical differences (P=.0001). This finding is in agreement with other studies done by Ammar (2009) and Chimello et al. (2002). There are two main reasons for this finding:

First, the gingival margins of the cervical restorations in this research may be at cementum or dentin where there is no enamel. In composite group, the adhesion between the material and enamel is stronger than the adhesion of the material with dentin. Also, the difference in thermal expansion between enamel and composite is smaller than the difference between dentin and composite. For glass ionomer groups, the bonding by the material is achieved in part by mechanical retention and in part by chemical chelating; the former playing a more important role. This confirms the reason why there is less microleakage in the gingival margin in which there is no enamel (Behjatolmoluk et al., 2007).

And second, the beveling of enamel at occlusal margins can be a great factor in this difference in microleakage between the gingival and occlusal margins. The beveling increases the surface area of the preparation for bonding and with the use of 37% phosphoric acid gel and bonding agent, a resin enamel hybrid layer formed while strengthening the marginal adaptation of the resin composites at occlusal margins and reducing the chance of microleakage (Qin and Liu, 2005).

In this present study, the difference in microleakage between thermocycled and not thermocycled groups was not significant statistically (P> 0.05). This finding is in agreement with other studies that reported the absence of any influence of thermocycling on microleakage (Doerr, 1996).

This finding may be due to the numbers of the cycles used in this research which were 200 cycles. Another reason can be that, this laboratorial method is not a suitable test to simulate the real significance of temperature changes in clinical conditions and various microleakage studies compared thermocycled and non-thermocycled groups and also the different numbers of cycles observed no statistically significant difference. However, in some studies there are significant differences in marginal microleakage of resin reinforced glass ionomer cement and resin composite restorations between thermocycled and non-thermocycled groups (Yap, 1997; Flavia et al., 2003).

It should be noted that, the results obtained from this study are based on in vitro data. For that reason, further studies should be done to evaluate the clinical performance of flowable composite, self-cure glass ionomer and resin modified glass ionomer cements using different methods of microleakage study.

Conclusion

Within the limitations of this study, it is concluded that:

- None of the three restorative materials completely sealed the tooth/restoration interface at occlusal and gingival margins.
- The degree of microleakage in the gingival margin was more than in the occlusal margin.
- There is a significant statistical difference found between the materials in occlusal margin. Flowable composite showed less leakage than chemically cured GIC and light-cured GIC.
- Thermocycling had no effect on microleakage in all groups at both occlusal and gingival margins.

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