Fracture Resistance of Primary Molars Restored with the Bonded Amalgam Technique Using Various Luting Agents”- An Invitro Study

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ABSTRACT

Objective: To compare the fracture resistance of primary molars restored with the bonded amalgam technique using various luting agents viz, Resinomer, Rely X U-100 and GC Fuji PLUS as the bonding agents. Materials: Sixty sound primary molars were selected and randomly assigned to one of four test groups of 15 teeth each, i.e. Group I, Group II, Group III, and Group IV. All four groups were prepared to a standard MOD cavity form and restored with amalgam. In Group I no luting agent was used, in Group II Resinomer, in Group III Rely X U100 and in Group IV GC Fuji PLUS was used respectively. Each Group was then subjected to compressive testing until fracture occurred. The mean loads at fracture of each group were statistically compared using ANOVA with ‘Games Howell Post Hoc’ test. Results: Group II-Resinomer (852.93Mpa) showed the highest fracture resistance followed by Group IV GC Fuji PLUS (733.11Mpa), Group III-Rely X U100 (644.83Mpa) and Group I-amalgam alone (637.70Mpa). Conclusion: Primary molars restored with bonded amalgam techniques using various luting agents showed an increase in fracture resistance when compared to conventional amalgam restorations.

KEYWORDS: Adhesion, Dental Amalgam, Fracture Resistance, Luting Agents

INTRODUCTION

Although there have been many important developments in the field of dental materials and minimally intervention techniques, but yet, in many parts of the world, most restorations tend to continue to be of a traditional form such as amalgam. The main therapeutic agent for restoring decayed teeth in dentistry is Amalgam. The oldest written record, reporting the use of amalgam in dentistry is found in a publication in 1528. Although, there is evidence of a decrease in the use, the various advantages of amalgam, such as cost, durability and ease of manipulation, still make amalgam as the first choice of restoration for posterior teeth. Conventional amalgam acts like an obturating material as it merely fills the space of prepared cavity, and thus, does not contribute to restore the fracture resistance of the tooth, which is compromised during cavity preparations. Besides, the provision for adequate resistance and retention form for amalgams require the removal of healthy tooth structure, and since amalgam does not bond to tooth structure, microleakage immediately after insertion is inevitable. Hence, to overcome these disadvantages of amalgam, adhesive systems like bonding agents that reliably bond to enamel and dentin have been introduced. Bonded amalgam restorations reduce need for mechanical retention features and resistance form which conserves sound tooth tissues. Bonding amalgam restorations help to restore tooth integrity and fracture resistance and also assist in the improvement of the marginal seal with potentially less sensitivity.

Now that there are newer adhesives and resin cement materials available to bond amalgam restorations, the technique of bonding amalgam restorations should gain popularity. However, there is little information available on resin cements such as Resinomer, GC Fuji PLUS, and Relyx™ U 100 that are currently being used as bonding materials and despite a large amount of research on the efficacy of bonded amalgam technique in permanent teeth, little research has addressed bonded amalgam technique in primary teeth. Since there is a paucity of

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information available in the area of bonded amalgam technique in primary teeth, this in vitro study was designed to assess the fracture resistance of bonded amalgam restorations in primary teeth using various luting agents, viz.

- Resinomer – Dual cured amalgam bonding or luting cement (Bisco) FIG 2A
- Relyx™ U 100 – Self-Adhesive Universal Resin Cement (3M ESPE) FIG 2B
- GC Fuji PLUS - Resin reinforced glass ionomer luting cement (GC CORP) FIG 2C

MATERIALS AND METHODS

60 freshly extracted primary molar teeth (FIG 1A) were collected and mounted on cold-cure acrylic resin blocks (FIG 1B) covering the entire length of the root, and were kept 1.0 mm short of the cementoenamel junction of the specimen to mimic support of the natural tooth. The base of the resin block was trimmed to expose the root tip in its apical one third to allow transmission of applied force entirely through tooth structure by preventing settling of the tooth within the acrylic mold during testing procedures. The mounted teeth were randomly divided into four groups (FIG 2A, 2B, 2C, 2D) and stored in saline at room temperature (FIG 3A). Mesio-occluso-distal (MOD) cavities were prepared using a #330 pear shape bur in a high-speed handpiece with water spray.

The size of the cavity preparation was made proportional to the dimensions of the tooth to minimize variations resulting from tooth size. Using a light brushing motion the occlusal outline form was prepared. The ideal depth of the cavity was approximately 1.5mm from the cavosurface margin. The length of the cutting end of #330 bur is 1.5 mm approximately, which helped in proper gauging of the cavity depth. The isthmus was 1/3rd of the intercuspal width, and the buccolingual walls were made slightly converging in an occlusal direction. To prepare the proximal box, the bur was placed at the marginal ridge and moved buccolingually in a pendulum like motion and in a gingival direction at the DEJ. The axial wall of the proximal box followed the same contour as the outer proximal contour of the tooth. The mesiodistal width of the gingival seat was 1mm, which was approximately equal to the width of #330 bur. The axiopulpal line angle was rounded.

After MOD cavity preparation all the four groups were restored with amalgam. In Group I no luting agent was used, in Group II Resinomer, Group III Rely X U100 and in Group IV GC Fuji PLUS luting agent was used according to the manufacturer's instructions. Restoration finishing and polishing was done. To prevent dessication...
of the specimens the specimens were stored in saline solution at room temperature for 14 days prior to testing. The fracture test was conducted in the UNIVERSAL TESTING MACHINE (FIG 3B). The specimen to be tested was placed on the lower compartment of the machine. A solid stainless steel rod of 5mm diameter was placed vertically on the occlusal aspect of the restored teeth so that it contacted only the inner cuspal slopes and not the restoration. A crosshead speed of 5mm/min was programmed on the machine and the specimen to be tested was subjected to compressive load application till the tooth fractured.

**RESULTS**

Results were expressed as Mean +/- SD. “One way ANOVA” test was used for simultaneous comparison of all groups and ‘Games Howell Post Hoc’ test for intergroup comparison. SPSS Software version 19 was used for statistical analysis of the data (Table 1).

<table>
<thead>
<tr>
<th>Study Groups</th>
<th>Mean Amalgam alone</th>
<th>Resinomer luting agent</th>
<th>Rely X-U 100</th>
<th>GC Fuji PLUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amalgam alone</td>
<td>637.7</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Resinomer luting</td>
<td>852.9</td>
<td>215.23 S</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rely X-U 100</td>
<td>644.8</td>
<td>7.12 NS</td>
<td>208.11 S</td>
<td>-</td>
</tr>
<tr>
<td>GC Fuji PLUS</td>
<td>733.1</td>
<td>95.41 NS</td>
<td>119.82 NS</td>
<td>88.28 NS</td>
</tr>
</tbody>
</table>

Table 1: shows the ONE WAY ANOVA test results, P<0.001 H5

One way ANOVA test was used for simultaneous comparison of fracture resistance of all groups. The results showed that difference was highly significant between the conventional group and the bonded Groups.

Among these Groups, Groups II, III, and IV representing the bonded amalgam restorations that were bonded with different luting agents exhibited statistically significant values for fracture resistance compared to Group I representing the conventional amalgam restorations without any bonding. The results showed a value for p<0.001 which is highly significant and from this it can be concluded that there are indeed significant differences statistically among the group means. Amongst all the Groups tested the restorations in Group II showed the best scores compared to the other groups.

Group II (852.93) > Group IV (733.11) > Group III (644.83) > Group I (637.70) Table 2.

**DISCUSSION**

Among the three test groups of bonded amalgam restorations, the group that was bonded with Resinomer luting agent gave higher values of fracture resistance (852.93mpa) and the group bonded with Rely X-U 100 luting agent gave the least results (644.83). Resinomer (Bisco Inc., Schaumburg, Illinois, USA) is a fluoride releasing, low-viscosity resin composite containing diarylsulfone dimethacrylate (DSDM). DSDM is a monomer which forms strong micromechanical as well as chemical bonds to all dental metals. Resinomer is intended to be used with fourth- or fifth-generation bonding agents such as All bond 2 or One-Step Plus (OS+). In the current study All bond 2, a fourth generation bonding agent was used. Resinomer, when used with All-bond 2, forms a high-strength adhesive seal to dentin and enamel that is beyond the cohesive strength of dentin. It also releases fluoride to help protect interproximal/subgingival margins. The low viscosity of Resinomer facilitates the formation of a mechanical union between amalgam and resin (Diefenderfer and Reinhardt).

In a 3year follow up study performed by Cannon et al. to evaluate the efficacy of bonded amalgam technique
using All-bond 2 adhesive system and Resinomer in combination with Tytin amalgam in primary teeth, showed a statistically significant results of bonded amalgam in comparison to the control group (with no bonding materials). Tangssoolwatana et al.8, found that All Bond 2/Resinomer was the most effective adhesive, in increasing the adhesion. All the authors who used All Bond 2 associated to Resinomer, concluded that, the use of this adhesive material is suitable for bonded amalgam restoration. Group IV that was bonded with GC Fuji PLUS luting agent also gave significantly higher values (733.11mpa). GC Fuji PLUS, is a self-cured luting agent. Consists of a powder and a liquid that are hand mixed for 20 seconds immediately before use. The powder is an aluminosilicate glass while the liquid is an aqueous solution of polyacrylic acid, 2-hydroxyethyl methacrylate (2-HEMA), and tartaric acid. GC Fuji PLUS is a hybrid material consisting of resin and glass ionomer compared to the traditional glass-ionomer luting agents such as Ketac-Cem, Fuji Ionomer Type I, etc. During the condensation of amalgam when the GC Fuji PLUS is still in early stage of setting, it flows moderately and intermingles with amalgam. Therefore, it provides both mechanical interlocking with amalgam and chemical bonding with the tooth structure. GIC can bond to metallic oxide, such as tin oxide and silver oxide, which are the components of dental amalgam. Hence, the bonding of freshly mixed Glass ionomer to newly mixed amalgam can be expected. Both conventional Glass ionomer and resin-modified materials have shown increased measurements of shear bond strengths at the dentin/amalgam interface which increases the retention of amalgam to tooth structure, thereby reducing the necessity of macromechanical features and conserving tooth tissue.9

In Group III (RelyX™ U100) the results obtained (644.83) were almost similar to that of the conventional group (637.70). RelyX™ U100 - self-adhesive resin cement is indicated for the permanent cementation of all-ceramic, composite, or metal restorations to implant abutments. The self-adhesive cements basic composition is similar to conventional resin cement, and in addition they also contain acid-functionaliased methacrylate or related monomers, as a polyacryl matrix structure, is required for effective chemical bonding to tooth. The setting reaction is an acid-base reaction within an aqueous environment. For this reason, it is recommended to avoid over drying the dentin surface while using these cements.10 In the current study RelyX™ U100 gave lower values compared to the other luting agents used. Amalgam bonding is purely micromechanical with micro and macrotag formation between the alloy, luting agent and the tooth structure (enamel and dentin). A study conducted by Bitter et al.10 concluded that, RelyX™ U100 show significantly lower number of penetrated dentinal tubules, have lower hybrid layer thickness and in only a few specimens the penetration of this cement into the dentinal tubules was found in comparison with conventional dual-cure cements. It was concluded that the smear layer was not dissolved consistently at the dentin.

This might be one of the possibilities of reduced micromechanical retention in the current study. Also, amalgam restorations require moisture free area to prevent delayed expansion. The over dry area might have also prevented the micromechanical retention. microtensile bond Strength of RelyX™ U100 was low on dentin surfaces (R. G. Viotti et al.11). The shear bond strength of RelyX™ U100 to human dentin was lower than the other materials used (Tantitrakarnwatana et al.12). There are no studies related to the use of RelyX™ U100 to bond amalgam. Further studies are required to evaluate the usage of this material in bonding amalgam and its role in enhancing the fracture resistance of the teeth. The conventional (non-bonded) amalgam restorations i.e., Group I without any bonding agent exhibited statistically significantly lower values (637.70mpa) for fracture resistance compared to the bonded groups. The restorative procedures tend to change the optimized coronal stress distribution. Hence, the coronal tissues may not be strong to withstand the masticatory forces and structural failures may develop. Therefore, restoration of a tooth should ideally recreate the original stress distribution in the remaining tooth structure. Many publications have emphasized the importance of bonded amalgam restorations over conventional amalgam restorations.13 Various studies14,15,16,17,18 have shown that prepared teeth fracture more readily than sound intact teeth.

CONCLUSION

Hence, within the limits of this in vitro study it can be concluded that the bonded amalgam restorations are more retentive and effective compared to the conventional (non-bonded) amalgam restorations. Different bonding agents can be used to bond the amalgam restoration. According to this study, resin cements and Glass ionomer cements can be highly effective in bonding amalgam restorations. Among all the Groups tested, the restorations in Group II which used Resinomer luting agent showed the best scores followed by GC Fuji PLUS compared to the other groups. Hence these luting agents can be used to bond amalgam and further studies are required to evaluate the use of RelyX™ U100 in bonding amalgam.

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