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Research Article

FRACTURERESISTANCE 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 increase in fracture resistance when compared to conventional amalgam restorations.

INTRODUCTION

Despite many important developments in dental materials and minimally intervention techniques, in many parts of the world, most restorations tend to continue to be of a traditional form, and the material most widely used in dentistry is still amalgam.[1] Amalgam is dentistry's main therapeutic agent for restoring decayed teeth. The oldest written record of the use of amalgam in dentistry is a publication in 1528 (Mathew *et al*., 2011; Craig and Powers, 2002). Dental amalgam restorations are reasonably easy to insert, are not overly technique sensitive, maintain anatomical form, have reasonably adequate resistance to fracture, prevent marginal leakage after a period of time in the mouth, can be used in stress bearing areas, and have a relatively long service life (Craig and Powers, 2002).

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Although there is evidence of a decrease in its use in the world, amalgam's cost, durability and ease of manipulation have persuaded many dentists to continue to use it as their first choice for restoring posterior teeth (Mach *et al*., 2002). Conventional amalgam is an obturating material as it merely fills the space of prepared cavity, and thus, does not restore the fracture resistance of the tooth, which is lost during cavity preparations (Mach *et al*., 2002). In addition, the provision for adequate resistance and retention form for amalgams may require removal of healthy tooth structure. Further, since amalgam does not bond to tooth structure, microleakage immediately after insertion is inevitable (Mach *et al*., 2002). So, to overcome these disadvantages of amalgam, adhesive systems that reliably bond to enamel and dentin have been introduced (Mach *et al*., 2002). Bonded amalgam restorations gives promise for reduced need for mechanical retention features and resistance form which conserves sound tooth tissues (Setcos *et al*., 1999).

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 (Setcos *et al*., 1999). 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 the large amount of research on efficacy of bonded amalgam technique in permanent teeth, little research has addressed bonded amalgam technique in primary teeth. Since there is paucity of 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 METERIALS

Sixty 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 so as to mimic alveolar support for the tooth. The base of the resin block was trimmed to expose a cross-section of the root in its apical one third. This allowed transmission of applied force entirely through tooth structure by preventing settling of the tooth within the acrylic during testing. The mounted teeth were randomly divided into four groups (Fig.3A, 3B, 3C, 3D) and stored in saline at room temperature (Fig.4A). Mesio-occluso-distal (MOD) cavities were prepared using a #330 pear shape bur in a high-speed hand piece 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 1.5mm 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 motion and in a gingival direction at the DEJ. The axial wall of proximal box followed the same contour as the outer proximal contour of the tooth. The mesiodistal width of 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. After restoration finishing and polishing was done. The specimens were then stored in saline at room temperature for 14 days prior to testing, to prevent dessication of the specimens. The fracture test was conducted in the Universal Testing Machine (Fig.4B). 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.

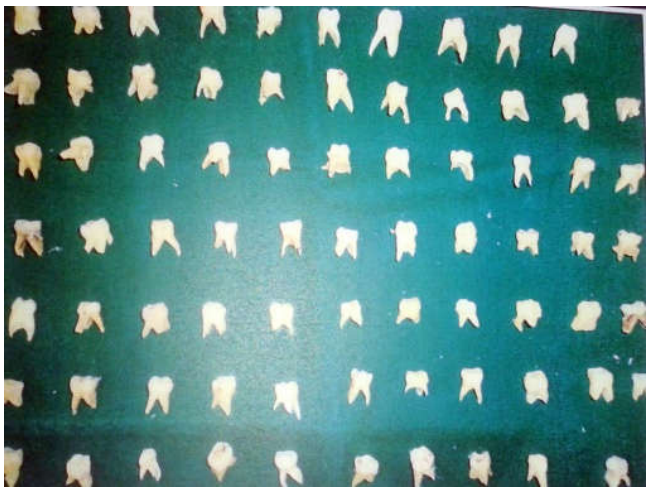
RESULTS

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 inter group comparison. SPSS Software version 19 was used for statistical analysis of the data. 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 groupsGroup II (852.93) >Group IV (733.11)>Group III (644.83) >Group I (637.70).

Games Howell Post Hoc test comparison method, found that each group mean was statistically significantly different when compared to the others. Restoration with Resinomer luting agent when compared with amalgam restoration was statistically significant. Restoration with Rely X -U 100 when compared with Resinomer luting agent was statistically significant and when compared with amalgam alone was not significant. Restoration with GC Fuji PLUS when compared with amalgam alone, Resinomer luting agent and Rely X U 100 was not Significant. Significant differences were observed among the adhesive groups, although some comparisons exhibited no statistically significant differences.

DISCUSSION

Among the three test groups of bonded amalgam restorations, the group that were 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+) (Germec *et al*., 2009). In the current study All bond 2, a fourth generation bonding agent was used. When used with All-bond 2, Resinomer forms a high-strength adhesive seal to dentin and enamel that surpasses the cohesive strength of dentin. At the same time, it releases fluoride to help protect interproximal/subgingival margins. The low viscosity of



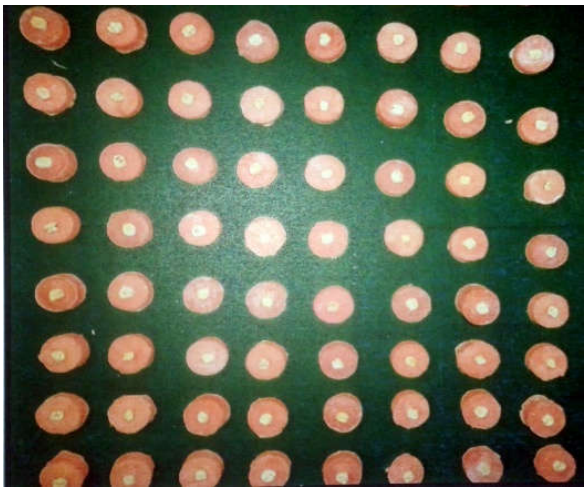


Fig. 1A. Extracted sound primary molars

Fig. 2A. Resinoimer luting agent

Fig 2C. GC fuji plus

Resinomer facilitates the formation of a mechanical union between amalgam and resin (Diefenderfer and Reinhardt) (Diefenderfer and Reinhardt, 1997) Cannon *et al.* (1999) performed a 3-year follow-up clinical study to evaluate the efficacy of bonded amalgam technique using All-bond 2 adhesive system and Resinomer in combination with Tytin amalgam in primary teeth. The study showed a statistical superiority of bonded amalgam in comparison to the control group (with no bonding materials).

Table 1. Shows the ONE WAY ANOVA test results

ONE WAY ANOVA TEST		
Study Groups	Mean	SD
Amalgam alone	637.70	85.68
Resinomer luting agent	852.93	149.29
Rely X-U 100	644.83	60.38
GC Fuji PLUS	733.11	197.59

P* Value, sig P<0.001 HS

Table 2. Inter group comparison done with Games Howell Post Hoc test

Study Groups	Mean	Amalgam alone	Resinomer luting agent	Rely X-U 100	GC Fuji PLUS
Amalgam alone	637.70	-	-	-	-
Resinomer luting agent	852.93	215.23 S	-	-	-
Rely X-U 100	644.83	7.12 NS	208.11 S	-	-
GC Fuji PLUS	733.11	95.41 NS	119.82 NS	88.28 NS	-

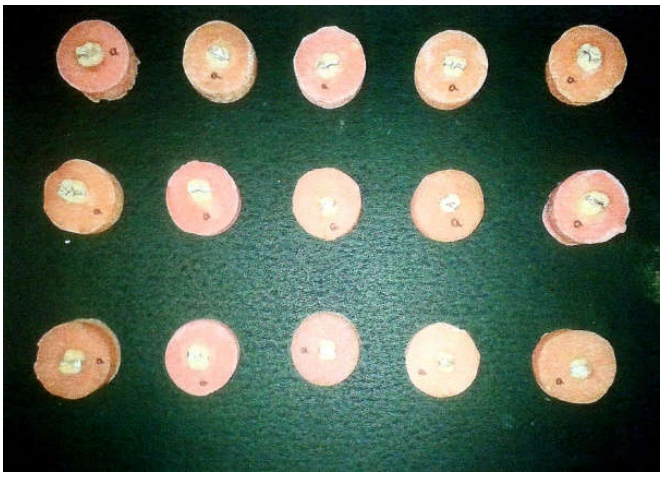


Fig 3A. Coventional Group I

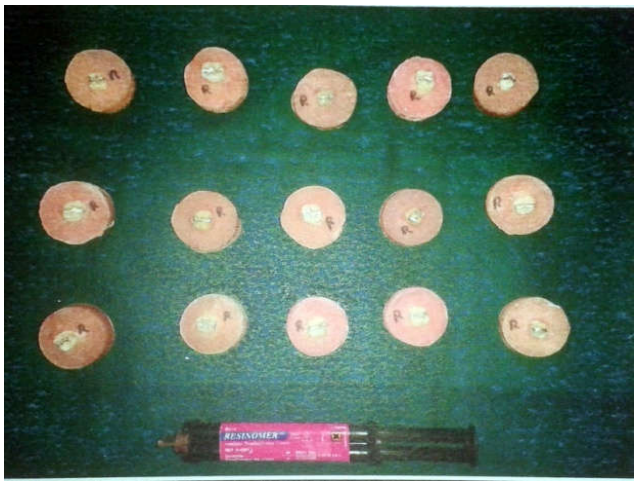


Fig. 3B. Resinomer Group II

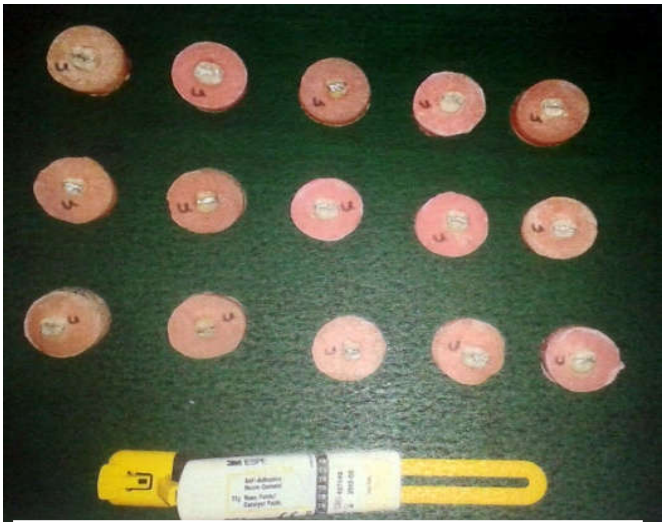


Fig. 3C. Rely X U100 Group III

Fig. 3D. Gc Fuji Plus Group Iv

Tangsgoolwatana *et al.* (1997) found that All Bond 2/Resinomer was the most effective adhesive, in increasing the adhesion. Although there are differences in methodology, the authors also used All Bond 2 associated to Resinomer, and according to them, the use of this adhesive material is suitable as a bonding agent for amalgam restorations. Group IV that were bonded with GC Fuji PLUS luting agent also gave significantly higher values (733.11mpa). GC Fuji PLUS, 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 differs from traditional glass-ionomer luting agents (e.g., Ketac-Cem, Fuji

Fig. 4A. Restored Teeth Stored In Saline

Fig. 4B. utm machine with specimen

Ionomer Type I, AquaCem) in that it is compositionally a hybrid material consisting of resin and glass ionomer. 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. It has been found that GIC can also bond to metallic oxide, such as tin oxide and silver oxide. Since tin and silver are the components of dental amalgam, 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, thus diminishing the reliance on macromechanical features which has the overall effect of conserving tooth tissue (Shivaughn *et al*., 2009). In Group III (RelyX™ U100) the results obtained (644.83) were almost similar to that of 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 basic composition of self-adhesive cements is similar to conventional resin cement, and they also contain additional acid-functionalised methacrylate or related monomers because effective chemical bonding to tooth requires a polyacid matrix structure. The setting reaction include the acid-base reaction within an aqueous environment. For this reason, it is recommended to avoid over drying the dentin surface while using these cements (Bitter *et al*., 2009). 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). Bitter *et al*. (2009) have affirmed that RelyX™ U100 showed a significantly lower number of penetrated dentinal tubules, lower hybrid layer thickness and the penetration of this cement into the dentinal tubules were found in only a few specimens 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 possibility 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 (Viotti *et al*. 2009). The shear bond strength of RelyX™ U100 to human dentin was lower than the other materials used (Tantitrakarnwatana *et al*., 2012). 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. When a restoration is carried out, it may change the optimized coronal stress distribution. As a result, the same coronal tissues may not be able to withstand the masticatory forces and structural failure develops. Therefore, restoration of a tooth ideally requires the recreation of the original stress distribution in the remaining tooth structure. Many publications have shown the loss of tooth stiffness for unbonded restorations and how it is almost recovered when restorations are bonded. It has also been shown that teeth with unbonded restorations fracture at lower loads (Davidson and Mjor, 1999). Various studies (Bassam Afram Hanna, 2011; Dias De Souza *et al*., 2002; Eakle *et al*., 1992; Oliveira *et al*., 1996; Pilo *et al*., 1998) have shown that prepared teeth fracture more readily than sound intact teeth.

Conclusion

Hence, within the limits of this in vitro study it is concluded that the bonded amalgam restorations are more retentive compared to the conventional (non-bonded) amalgam restorations. Different materials can be used to bond the amalgam restoration. This study found that, particularly resin

cements and Glass ionomer cements can be highly advantageous for bonding amalgam restorations because of their high retentive strength, and 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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