Fracture Resistance of Premolars with Bonded Class II Amalgams

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Clinical Relevance
The bonding amalgam technique using Scotchbond Multi-Purpose Plus increased the fracture resistance of maxillary premolars with retentive preparations, and Panavia F cement did not present better results than the group restored only with silver amalgam.

SUMMARY
This study evaluated the fracture resistance of maxillary premolars with MOD cavity preparation and simulated periodontal ligament. The teeth were restored with silver amalgam (G1), Scotchbond Multi-Purpose Plus and silver amalgam (G2) and Panavia F and silver amalgam (G3). After restorations were made, the specimens were stored at 37°C for 24 hours at 100% humidity and submitted to the compression test in the Universal Testing Machine (Instron). The statistical analysis of the results (ANOVA and Tukey Test) revealed that the fracture resistance of group 2 (G2=105.720 kgF) was superior to those of groups 1 (G1=72.433 kgF) and 3 (G3=80.505 kgF) that did not differ between them.

INTRODUCTION
Silver amalgam, used in dentistry since 1826 (Staninec & Holt, 1988), is still frequently used to restore proximobuccal cavities in posterior teeth due to its favorable properties, easy handling characteristics and obtaining of appropriate proximal contacts (Gwinnett & others, 1994). However, one of the disadvantages of the extensive restorations in amalgam is that, since it does not stick to the dental structure, it does not reinforce the weak walls of the cavity (Jagadish & Yogesh, 1990; Oliveira, Cochran & Moore, 1996) and they need retentive walls or additional mechanical retenions, such as posts, pins or grooves for their stability, reducing the healthy tooth structure and, consequently, weakening the tooth (Staninec & Holt, 1988; Staninec, 1989; Gwinnett & others, 1994).

Amalgam cannot reinforce weak walls because of its low resilience and high modulus of elasticity. Therefore, it is necessary to remove the enamel with no support of dentin in order to reduce the possibility of coronary fracture (El-Sherif & others, 1988). This is evidenced by the fact that 13% of the amalgam restoration replacements...
are due to the fracture of cusp(s) (Lagouvardos, Sourai & Douvitsas, 1989; Boyer & Roth, 1994; Pilo, Brosh & Chweidan, 1998). The anatomic form of posterior teeth with cusps and fossae present a design with a tendency to deflect the cusps under stress (joynt & others, 1987; Mondelli & others, 1980); however, secondary decay, abrasion or erosion and extensive preparations also predispose the tooth to fracture (Khers & others, 1990) because removing the marginal ridge and increasing the isthmus occlusal width considerably weakens the tooth (Mondelli & others, 1980; Joynt & others, 1987; Lagouvardos & others, 1989; Pilo & others, 1998).

Denby & Torney (1976) and Santos & Meiers (1994) proposed using adhesive materials, aiming to reinforce the coronary structure (Denby & Torney, 1976; Santos & Meiers, 1994). The union agent applied to the conditioned dental surface prior to amalgam insertion seems to increase the fracture resistance of posterior teeth (Joynt & others, 1987). The technique consists of amalgam condensation on the uncured adhesive, generating an ionic and mechanical adhesion between the etched tooth surface and the adhesive resin and a mechanical interlocking and adhesion mediated by Van der Waals forces between the adhesive resin and amalgam that explain the possible increase in the fracture resistance of teeth weakened by the cavity preparation (Staniec & Holt, 1988; Gwinnett & others, 1994; Pilo & others, 1998).

The technical difficulties, increase of clinical time and cost of the procedure are limitations of the technique that justify studies to evidence the benefits stated in the literature (Khers & others, 1990; Boyer & Roth, 1994; Christensen, 1994).

This work evaluated the fracture resistance of maxillary premolars with mesio-occlusal-distal cavity preparations and convergent walls restored with the adhesive amalgam technique.

METHODS AND MATERIALS

Twenty-four non-curious recently extracted maxillary premolars were stored in 10% formalin solution (pH=7.0) at room temperature for no longer than one month. After they had been cleaned with periodontal curettes, the teeth received a radicular covering with wax (n° 7) in order to form a 0.3 mm thick film controlled with digital caliper (Digimess, São Paulo, Brazil 01415-021), corresponding to the periodontal ligament space (Coolidge, 1937).

The roots were inserted in polystyrene resin cylinders, exposing 2 mm of the root surface below the cementum-enamel junction. Next, the wax that occupied the 0.3 mm space was removed with hot water and substituted by urethane rubber material (PU-501/Neuro–SEM TOGO), São Paulo, Brazil 01349-518) which, besides simulating the periodontal ligament, fastens the root in its artificial alveolus (Sharnagl, 1998).

The intercuspal distance in the occlusal surface and the height of the buccal cusp top to the enamel-cementum junction of each tooth were measured using a digital caliper to standardize the cavity preparations.

MOD cavities were prepared with convergent walls with no approximal boxes, using a diamond bur FG 3145 (KG Sorensen, Barueri, Brazil 01981-340) in a high-speed water cooler handpiece fixed in a specially designed jig (Figure 1). This device is also constituted by an apparatus that standardizes the cavity preparation by holding the cylinders where the teeth were included, and allowing its buccal-lingual and mesio-distal accurate movements (0.001 mm) in order to make the cavities with the dimensions previously established. The isthmus width was 3/5 the distance between the cusp tips, and the pulpal depth was 3/5 the height of the crown. Soon afterwards, a diamond bur FG 1016 (KG Sorensen) was positioned tangent to the floor of the preparation penetrating about 1 mm in the base of the buccal and lingual cusps in order to weaken them. The width of the cavity preparation was checked in the occlusal portion and the pulpal depth was measured regarding buccal cusp top with a digital caliper. The preparations were finished with the same diamond bur (FG 3145) in a low-speed handpiece (Figure 2). The teeth were rinsed with an air-water spray, then randomly divided into three groups (n=8). Group 1: teeth restored with silver amalgam using alloy Permite C (SDI, São Paulo, Brazil 05421-030) and the conventional restoration technique (Gwinnett & others, 1994). Group 2: dentin adhesive system Scotchbond Multi-

![Figure 1. Precision instrument utilized to prepare the cavities: A diagram. A: Screw that controls high speed bending. B: High-speed water cooler handpiece positioned. C: Premolar in polystyrene cylinder resin. D: Instrument that moves the sample in the mesio-distal direction. E: Precision instrument that regulates the depth of the preparation. F: Screw that controls the position of the depth controller. G: High-speed controller. H: Instrument that moves the sample in the buccal-lingual direction.](image-url)
Purpose Plus (SBMP Plus–3M Dental Products, Campinas, Brazil 13001-970) was applied before the insertion of the amalgam. Group 3: resin cement Panavia F (Kuraray Co, Osaka, Japan 1-12-39) was used before the teeth were restored with Permite C. The bonding agents’ components used in the adhesive amalgam technique were applied according to manufacturer’s instructions.

The specimens were stored for 24 hours in 100% relative humidity at 37°C and the fracture test was conducted in an Instron testing machine (Instron Corp, Canton, England 02021-1089) with 500 Kgf load. A 4 mm diameter steel sphere contacted the buccal and lingual cusps of the tested teeth at a crosshead speed of 0.5 mm/min, until fracture occurred (Figure 3).

RESULTS

The results obtained in this study are presented in Table 1. The mean values for the three groups were: G1-72.433 kgf; G2-105.720 kgf; G3-80.505 kgf. ANOVA test was made and showed significant statistical differences among the groups. Tukey test, α=0.05, was used to compare the statistical differences among the experimental groups, and its results are showed in Table 1 and Figure 4. Analyzing Table 1, the Tukey test presents the following results: SB presented the highest bond strength means that was statistically different from the other groups; AM and PAN presented statistically similar values.

DISCUSSION

Employment of adhesive systems under amalgam restorations is due to the immediate reduction of the marginal leakage (Varga, Matsumura & Masuhara, 1986; Simizu, Uii & Kawakami, 1987; Caron & others, 1996), capacity of amalgam retention in the cavity, what makes possible the accomplishment of cavity preparations with no mechanical retentions, preserving dental structure (Lacy & Staninec, 1989; Staninec, 1989; Charlton, Moore & Swartz, 1992) and the immediate reduction of the postoperative sensibility (Fusayama & others, 1979; Lacy & Staninec, 1989; Trushkowsky, 1991).

On the other hand, coronary fractures in posterior teeth with wide cavities are not rare in dental practice (Lagouvardos & others, 1989; Khers & others, 1990) and, according to Mondelli & others (1980), the most frequent causes of this fracture type are the inadequate manipulation of the restorative material and the geometric form of the preparation, due to the minute amount of the remaining dental structure. Cavity preparations with parallel walls and width of 2/5 of the intercuspidal distance were restored by the adhesive amalgam technique, and there was no significant difference among the appraised groups (silver amalgam; SBMP and amalgam; Panavia F and amalgam), probably due to the significant amount of remaining dentin under the cusps, providing them support and flexibility during the experiment (Dias de Souza & others, 2001). Therefore, in order to accomplish this work, in this study, this cavity preparation was idealized with

Figure 2. Aspect of MOD cavity preparation before restoration.

Figure 3. Steel sphere to provide occlusal loading on the cusps.

Figure 4. Illustrative graphic of means and standard deviations for the fracture resistance test.

AM: Silver amalgam  
SB: SBMP Plus and silver amalgam  
PAN: Panavia F and silver amalgam
Table 1: Means and Standard Deviations for the Fracture Resistance Test

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean</th>
<th>Tukey Grouping</th>
</tr>
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<tbody>
<tr>
<td>Amalgam (AM)</td>
<td>72.433 (+4.357)</td>
<td>A</td>
</tr>
<tr>
<td>Scotchbond MP Plus (SB)</td>
<td>105.720 (+17.996)</td>
<td>B</td>
</tr>
<tr>
<td>Panavia (PAN)</td>
<td>80.505 (+6.206)</td>
<td>A</td>
</tr>
</tbody>
</table>

Significant differences between SB and the others (p<0.05) by Analysis of Variance.

a spherical diamond bur tangent to the floor and the dentin structure was removed to weaken the cusps, aiming to simulate a real clinical situation. Besides, Gelb, Barouch & Simonsen (1986) stated that the larger the width of the preparation, the smaller the tooth resistance. Therefore, the preparations were made with a width of 3/5 of the intercuspidal distance and removal of the marginal crests.

The statistical analysis revealed no significant statistical difference among the fracture resistance values for the groups restored with amalgam (AM) and Panavia F and amalgam (PAN), but these were significantly smaller than the values found for the group restored with SPMP Purpose Plus and silver amalgam (SB). These results differ from those found in the work of Pilo & others (1998), in which the smallest fracture resistance values were presented by the group restored with SBMP Plus and the authors attributed that to the absence of filler particles. However, this study’s result agrees with Mishell, Share & Nathanson (1984), who found larger fracture resistance in the group restored with adhesive for enamel and dentin and amalgam than in the group restored only with amalgam. Chalkley & Jensen (1984) explained that when adhesives for enamel and dentin are applied on a previously conditioned surface, the union force of the restorative material to the tooth is twice as large as when there is no application of those systems. Besides, this larger resistance is due to the extensive available area for adhesion inside the preparation (Eakle, 1986). Another important factor is that the adhesive of the SBMP Plus system presents high resilience as a result of the filler absence and also has the capacity to form a thicker, uniform hybrid layer that results in reliable adhesion values, reinforcing the dental crown (Söderholm, 1997).

The low fracture resistance values for the group restored with Panavia F and amalgam were probably related to the self-etching primer supplied by the manufacturer. The acidic monomers of this primer dissolve and incorporate the smear layer into the mixture as it also demineralizes the superficial dentin and encapsulates the collagen fibers and the hydroxyapatite crystals (Nishida & others, 1993; Gordan & others, 1998). This union mechanism presents satisfactory initial values of adhesion; however, the superficial penetration of the adhesive results in a slightly thicker hybrid layer with high modulus of elasticity, reducing the capacity to absorb loads and the reinforcement capacity (Uno & Finger, 1996). It is also known that, below the hybrid layer, an area of brittle dentin is formed by the continuous conditioning, which could damage the adhesion values in 24 hours (Söderholm, 1997).

On the other hand, the cement Panavia F was supposed to provide elasticity to the cavity walls, increasing the fracture resistance. However, this cement possesses a high amount of filler, increasing its modulus of elasticity, which reduces its capacity to absorb tensions (Eliades, 1994; Phrakkanon, Burrow & Tyas, 1998).

It is important to point out that making restorations using Panavia F in the technique of the adhesive amalgam presents difficulties since there is no control on the amount of cement inserted in the cavity, and the cement excess tends to adhere to the condenser and to extravasate the cavity, hindering the finalization of the restoration, which increases the clinical time and promotes a rough surface in the cervical third of the restoration. This could lead to future problems (Mahler & others, 1996).

For this reason, the authors can state that, in teeth weakened by wide cavity preparations, it is interesting to apply a union system that makes use of total conditioning of dental surface and adhesive for enamel and dentin such as SBMP Plus, prior to the amalgam insertion, aiming to prevent dental fracture.

**CONCLUSIONS**

Based on the results found in this study, the authors can conclude that SBMP Plus, associated with the silver amalgam, increased the fracture resistance of maxillary premolars with wide cavity preparations and convergent walls when compared to the groups restored only with amalgam or with Panavia F associated to the silver amalgam. Therefore, it may be important for clinicians to evaluate the tooth condition, applying adhesives in the cavity preparations whenever the tooth presents considerable weakening.

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**References**


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Charlton DG, Moore BK & Swartz ML (1992) In vitro evaluation of the use of resin liners to reduce microleakage and improve retention of amalgam restorations Operative Dentistry 17(3) 112-119.


