Evaluation of the shear bond strength of alloybond amalgam adhesive with and without using of different retentive means

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ABSTRACT
Background: Many problems result with the use of pins and with development of the dentin adhesives reason for minimizing of dentin pin usage have emerged. The aim of the study was to evaluate the shear bond strength of alloybond amalgam adhesive with and without using of different retentive means.
Materials and Methods: Fifty sound 1st premolar teeth of similar size and shape were used in this study. The occlusal surfaces were ground to have flat superficial dentin. The specimens divided into five groups which received different retention methods (two pins, alloybond-SDI Australia, two grooves (1mm depth and 1mm in diameter). The specimens were stored at 37°C for 24 hrs after thermocycling before testing by using Instron testing machine, with cross head speed 0.5 mm/min until the amalgam fracture from the tooth. The mode of failure which is adhesive, cohesive or mixed was examined.
Results: There was a high significant differences (p<0.01) among all the groups. Highest shear bond strength values were seen in group of 2 pins and alloybond and the lowest bond strength were related with the use of 2 grooves while the other groups were between them.
Conclusion: The use of pins with the alloybond produced superior shear bond strength and there was no significant difference between the use of pins, and the use of 2 grooves with alloybond.
Keywords: Shear bond strength, amalgam, bonding agent.

INTRODUCTION
Dental amalgam has been the material of choice for restoring posterior teeth for more than 100 years (1), because it has been considered as stable, good life expectancy, easiness of handling and cost-effective restorative materials (2).

The success of the restorations depends on bonding them to the hard tooth structure that will retain the restorations to the cavity preparation and prevent microleakage (3). Although amalgam has good mechanical properties, it does not bond to the tooth structure, so the mechanical retention forms that may include additional grooves, slots, and retentive pins are prepared in the tooth to achieve the needed retention (4).

On the other hand, the use of pin results in many problems such as perforation into dental pulp and periodontal ligament, crazing and stress within dentin, heat generation, pulpal inflammation, micro-leakage and weakening of the restoration (5,6). Therefore, with the increased strength of dentin bonding agents, coupled with the use of retentive slots, grooves, and channels led to reduction in the use of pins (7).

As well as with the development of amalgam bonding, there is no difference in the performance of pinned-retained amalgam restoration and bonded amalgam restoration (8).

MATERIALS AND METHODS
Fifty sound non-carious human maxillary first premolar teeth freshly extracted for orthodontic purposes, of comparable size and shape, were collected and stored in deionized distilled water until used. The tooth’s root was notched and embedded in cold cure acrylic block. The occlusal surface was ground with 600-grit silicon carbide abrasive paper under running water perpendicular to the long axis of the tooth by using automated polisher to have flat uniform polished, and smooth dentin surface. The coronal diameters of each specimen were measured by a vernier, by measuring the greatest facio-lingual and mesio-distal dimensions of each one at the level of the preparation to find interface surface area. Specimens were randomly divided into five groups. Each group consisted of ten teeth which received one of the following treatments and as follows:

Group 1: 10 teeth treated with amalgam retained by two pins only (control group).
Group 2: 10 teeth treated with amalgam retained by two pins and alloybond.
**Group 3**: 10 teeth treated with amalgam retained by alloybond.

**Group 4**: 10 teeth treated with amalgam retained by two grooves.

**Group 5**: 10 teeth treated with amalgam retained by two grooves and alloybond.

The two pin-holes were prepared for (groups 1 and 2) at 90 degree to the prepared flat occlusal surface by using the self-limiting twist drill to the depth of 2 mm in dentin, which was mounted on straight hand-piece that was fixed to the handle of the surveyor at constant speed of 6000 rpm. After that, the pins were fractionally inserted to the pin-hole. The two pins were placed, one for each missing cusp buccally and lingually 1 mm from the dentino-enamel junction. The depth of pin was 2 mm in dentin and 2 mm for the amalgam core.

The two grooves were prepared (for groups 4 and 5) at 90 degree to the prepared flat tooth surface by using the fissure bur of 1 mm diameter (measured by vernier) to the depth 1 mm with water coolant. The fissure bur was mounted on a straight hand-piece that was fixed to the handle of the surveyor at constant speed of 6000 rpm. Each groove was prepared 1 mm from the dentino-enamel junction, one in each position of the missing cusp buccally and lingually at the same position of the pins application.

Alloybond bonding agent was applied to the prepared tooth surfaces for groups 2, 3, and 5 according to manufacturer instructions. The dentin surface was etched by 37% phosphoric acid gel for 20 seconds then rinsed with water spray for 15 seconds, and dried with a gentle air stream for 2 seconds at the distance of 1 cm to remove the excess water and to keep the dentin surface moist.

The primer was applied to the etched surface by a brush tip (two saturated brush tips), and blown gently with dry air syringe for 2 seconds to evaporate the solvent and leave the surface glossy. The alloybond primer was cured with light cure for 10 seconds.

The alloybond adhesive was applied by mixing one drop of alloybond base and one drop of alloybond catalyst to cover all the surfaces by a brush tip. The amalgam was applied within 60 seconds of the alloybond adhesive application. Then thermo-cycling test was comprising 500 cycles in water baths alternated between 5 °C and 55 °C, starting after 24 hours storage in water at 37°C. The exposure to each bath was 30 seconds, and the transfer time between the two baths was 5 seconds.

The specimen was tested for failure by an Instron universal testing machine with crosshead speed of 0.5 mm/min. (9) until the amalgam separated from the tooth under the vertical load producing shearing stress.

After shear testing procedure, the mode of failure of the whole specimens was examined by stereomicroscope and three categories were defined for modes of failure:

1) Adhesive failure: Representing the fracture of the amalgam core restoration at the interface between the dentin surface and amalgam.
2) Cohesive failure: Representing the fracture that occurs in either amalgam or dentin.
3) Mixed failure: Occurring when the amalgam was still partially bonded to the dentin (partially adhesion/partially cohesion).

**RESULTS**

The results obtained represented the shear bond strength of dentin to the amalgam. The descriptive statistics of the results (Table 1) showed a variation in the means values between the groups with the highest mean of shear bond strength value was related to group 2 (two pins and alloybond), and the lowest mean value was related to group 4 (two grooves only), while groups 1, 3 and 5 were between them.

One-way analysis of variance (ANOVA) test was used to show comparison of significance among the 5 tested groups (Table 2). The results showed that there was a highly significant difference at (P<0.01) between the different tested groups.

Further analysis of all data was used to examine the difference between each two groups by using the Student-t test (Table 3). It showed that there was a significant difference (p<0.05) between the control group and group 2 (two pins and amalgam), and there was a non significant difference between the control group and group 5 (two grooves and alloybond), and group 3 versus group 5, but there were highly significant difference between other tested groups.

The modes of failure of the whole specimens after shear testing procedure were evaluated. The number and the percentage, and the bar chart of the mode of failure for each group were represented in figure 1.

**DISCUSSION**

Under the condition of this study, the result showed that the use of 2 pins alone produced higher mean SBS values than the use of alloybond alone. This result agrees with the result of Sen et al. (4), who used the Panavia EX as a bonding agent and they found the shear bond strength of 2 pins was higher than the shear bond strength of this bonding agent.
Hadavi et al.\(^{(10)}\), who used All-bond 2 and Amalgam-bond plus and compared with TMS pin, found these two bonding systems produced higher SBS than pin because the addition of these two bonding systems had been reported to reduce dentin permeability with high dentin sealing properties, and high bond strength to dentin with increase in fracture resistance for restored teeth.

Comparing the results of using 2 pins with the results of using 2 grooves and alloybond, found that there was no statistical difference between them because the resistance to a shearing load created by amalgam bonding may be equal to the resistance provided by mechanical features such as pins. This explanation coincided with the conclusion of Summitt et al.\(^{(11)}\), who found the bonded amalgam restorations were performed as well as the mechanically retained restorations.

By comparing the mean shear bond strength value for alloybond in this study (3.96 MPa). This value was lower than those recorded by Duke et al.\(^{(12)}\) they recorded the mean shear bond strength value about (22.1 MPa) which is equal to Amalgam-bond plus and higher than All-bond 2. As well as, the results showed that the use of adhesive bonding agent (alloybond) with pins provided higher shear bond strength than the use of pins alone. This result agrees with the results of Lo et al. and Sen et al.\(^{(13,4)}\), who concluded that the use of bonding agents with pins increased the shear bond strength of amalgam cores. This was supported by Imbery et al. and Burgess et al.\(^{(14,15)}\), they evaluated that the adhesives combined with pins provided significantly greater resistance to the fracture than pins or adhesive alone.

The mode of bond failure in this in-vitro study was either adhesive or mixed type, with less frequent cohesive through the amalgam. The adhesive failure was the predominated type of failure in the groups of pins with or without bonding agent where the pinned restorations were dislodged from dentin. This may be attributed to the stress concentration in dentin around the pin that led to failure in mechanical retention of dentin around the pin and failure at the dentin / amalgam interface \(^{(13)}\). The cohesive failure through the amalgam was found with pinned amalgam that may be indicated to the use of pin with amalgam led to weakening the amalgam restoration \(^{(16)}\). The mixed failure was found generally in the groups of using alloybond that may indicate the mode of failure of bonded amalgam was the mixed failure. This finding was supported by Setcos et al.\(^{(17)}\), who reported the mode of failure of bonded amalgams generally mixed.

### REFERENCES


### Table 1: Means, minimum, maximum values and of SBS values, standard deviation (SD) for each group.

<table>
<thead>
<tr>
<th>Groups</th>
<th>No</th>
<th>Mean MPa</th>
<th>Max value</th>
<th>Min value</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1 (two pins+amalgam)</td>
<td>10</td>
<td>5.7</td>
<td>7.42</td>
<td>3.59</td>
<td>1.42</td>
</tr>
<tr>
<td>G2 (two pins+alloybond+amalgam)</td>
<td>10</td>
<td>6.81</td>
<td>8.28</td>
<td>5.54</td>
<td>0.86</td>
</tr>
<tr>
<td>G3 (alloybond+amalgam)</td>
<td>10</td>
<td>3.96</td>
<td>5.34</td>
<td>3.15</td>
<td>0.59</td>
</tr>
<tr>
<td>G4 (two grooves+amalgam)</td>
<td>10</td>
<td>0.89</td>
<td>1.26</td>
<td>0.50</td>
<td>0.23</td>
</tr>
<tr>
<td>G5 (two grooves+alloybond+amalgam)</td>
<td>10</td>
<td>4.52</td>
<td>6.68</td>
<td>3.51</td>
<td>1.08</td>
</tr>
</tbody>
</table>

### Table 2: Analysis of variance (ANOVA) test of SBS for all groups

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p.values</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>200.074</td>
<td>4</td>
<td>50.018</td>
<td>57.797</td>
<td>0.000</td>
<td>H.S</td>
</tr>
<tr>
<td>Within Groups</td>
<td>38.944</td>
<td>45</td>
<td>0.865</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>239.018</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>
Table 3: Student t-test to compare the mean shear bond strength values between each two groups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>t. values</th>
<th>Df</th>
<th>p. values</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1 &amp; G2</td>
<td>2.11</td>
<td>18</td>
<td>0.049</td>
<td>S</td>
</tr>
<tr>
<td>G1 &amp; G3</td>
<td>3.56</td>
<td>18</td>
<td>0.002</td>
<td>H.S</td>
</tr>
<tr>
<td>G1 &amp; G4</td>
<td>10.55</td>
<td>18</td>
<td>0.000</td>
<td>H.S</td>
</tr>
<tr>
<td>G1 &amp; G5</td>
<td>2.08</td>
<td>18</td>
<td>0.052</td>
<td>N.S</td>
</tr>
<tr>
<td>G2 &amp; G3</td>
<td>8.61</td>
<td>18</td>
<td>0.000</td>
<td>H.S</td>
</tr>
<tr>
<td>G2 &amp; G5</td>
<td>5.23</td>
<td>18</td>
<td>0.000</td>
<td>H.S</td>
</tr>
<tr>
<td>G3 &amp; G5</td>
<td>1.45</td>
<td>18</td>
<td>0.164</td>
<td>N.S</td>
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<td>G4 &amp; G2</td>
<td>20.89</td>
<td>18</td>
<td>0.000</td>
<td>H.S</td>
</tr>
<tr>
<td>G4 &amp; G3</td>
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<td>18</td>
<td>0.000</td>
<td>H.S</td>
</tr>
<tr>
<td>G4 &amp; G5</td>
<td>10.45</td>
<td>18</td>
<td>0.000</td>
<td>H.S</td>
</tr>
</tbody>
</table>

Figure 1: Bar chart showing the percentage of the mode of failure for all groups.

4- Sen D, Nayir E, Cetiner F. Shear bond strength of amalgam reinforced with a bonding agent and/or dentin pins. Prosthett Dent 2002; 87(4): 446-50.
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