A Comparison of Shear Bond Strength of Two Different Techniques with that of Initially Bonded Brackets

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ABSTRACT

Introduction: Bonding failure is recognized as the main concern in the daily practice of orthodontics. The failed bracket are usually rebonded on the tooth surface and several techniques have been used such as sand-pining and re-etching to enhance the effectiveness of bracket bonding to teeth surface. However, there are few investigations examined. The bond strength of bracket and the effectiveness of enhancement techniques have never been studied.

Materials and methods: In this investigation, the shear bond strength of two different rebonding techniques of sandblasting and re-etching which are common in dentistry were evaluated and compared with primary bonding strength.

Results: The mean shear stress for primary bonding interface (control samples) of brackets was 172.11 kg force/cm². These values for rebonded brackets using two techniques of sandblasting and re-etching were 165.89 kg force/cm² and 144.23 kg force/cm², respectively.

Conclusion: However, there was no significant difference in the shear strength responses of three groups. The results of the study showed that both techniques of rebonding of failed brackets can provide effective bonding strengths similar to the primary strength.

Keywords: Bracket, Bonding, Sandblasting, Shear bond strength.

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INTRODUCTION

Orthodontic treatment usually requires the use of fixed appliances. These appliances consist of attachments, are bonded directly to the tooth surface, and should remain until the end phase of active treatment. However, some of them fail in service. Decision of what to do with debonded or inaccurately positioned brackets that require repositioning during treatment are commonly faced in orthodontic specialty. In orthodontics, as well as in other fields of dentistry, there is a tendency to streamline the technical procedures to reduce chair time and treatment costs. The reduced cost of using recycled brackets represents a significant financial advantage when bonding orthodontic brackets.

From a clinical point of view, the success of bonding is of major importance. Fortunately, this bond is fairly strong enough to bear occlusal stress and shear forces. However, bonding failure frequently happens especially in youngsters in practice of orthodontics. This makes the subsequent appointment longer and troublesome. In addition, some technical errors may weaken this attachment, i.e. moisture control, clinical technique and bonding material.

Most orthodontic brackets are made of austenitic stainless steel, which contribute in chrome-carbide compounds formation that precipitate at temperatures between 600°C and 800°C. This process leads to disintegration of the metal alloy and weakens its structure. In addition, corrosion strength decreases due to chromium loss via carbide precipitation.

Preparing same bracket for rebonding is performed in different ways. Recycling as to remove the remnant composite from the base of bracket to maintain its retentive configuration is a method of rebonding. However, this preparation process is technically performed by four means:

Heat treatment: Composite is burned from bracket base and then the formed oxide layer is removed with an electropolishing device. This, however, can alter the microstructure of bracket mesh. Unfortunately, steel bracket at 600 to 800°C heat converts to chrome-cobalt compound. This phenomenon results in weakening the microstructure of bracket causing low corrosion strength, because of disintegration of metal compound.

Chemical removal: Chemical solvent may be applied for composite removal from the base of bracket to maintain its retentive configuration is a method of rebonding. However, this preparation process is technically performed by four means:

Sandblasting method: The bracket base is cleaned under compressed air flow with silicon carbide stone particles.
This procedure is also proposed with aluminum oxide particles. Sandblasting provides better microroughness and subsequently better bonding and leading to better micromechanical retention. This method was also recommended for new brackets leading to improved bond strength.\textsuperscript{13,14}

Re-etching technique: There is an evidence that composite surface becomes porous when exposed to etching gel.\textsuperscript{15} This creates a new micromechanical surface on bracket and more retentive when bonded to tooth.

The effect of recycling depends on the type of reconditioning process used, the type of alloy from which the bracket is constructed, whether the bracket is constructed using milling or casting, and whether the bracket has a mesh pad or a non-mesh undercut integral pad.\textsuperscript{16}

This process increases the microasperity of the bracket mesh; the area of composite bonding. Aluminum-oxide blasting technique was originally introduced to improve the mechanical retention of new brackets and bracket bonding to restore teeth as well as the tooth surface preparation.\textsuperscript{13,14}

Many in vitro studies evaluating the effect of recycling on bracket bond strength have shown that reconditioning produces a reduction in bond strength which is statistically significant compared with new brackets, both for stainless steel and ceramic brackets.\textsuperscript{2,3,11,17,18} The recycling techniques may also produce a slight change in bracket slot, distortion of bracket, and a reduced resistance to corrosion.\textsuperscript{19}

This study was conducted to compare shear bond strength (SBS) of two rebonding methods with that of initially bonded brackets.

MATERIALS AND METHODS
Fifty sound-extracted premolars were used for this purpose. They were rinsed in tap water, periodontal tissue was removed and samples were submerged in normal saline at 4°C for 3 months until use. The solution was renewed every 2 weeks.\textsuperscript{4} The root of teeth were vertically stabled in self-cure methyl acrylate blocks, using PVC rings.\textsuperscript{20} Finally, after polymerization, only crown of the teeth was accessible (Fig. 1). Then, buccal surfaces of the samples were cleaned with pumice with slow-speed handpiece for 15 seconds. The surface was subsequently dried with air flow for 10 seconds. After etching with 37% phosphoric acid for 30 seconds, all teeth were rinsed and dried for 20 seconds. Using a Boom’s gauge, premolar brackets were placed at 4 mm height. Brackets were 0.022" slot edgewise type (3M Unitek, CA, USA) and no-mix composite (Resilience, Ortho Technology, FL, USA) was used for bonding.

After 24 hours, all brackets were debonded under Instron blade (Zwick/Roell Z020, Universal Testing Machine, Germany) at the cross head speed of 0.5 mm/min for SBS measurement (Fig. 2). Then, samples were divided in two groups: (a) 25 teeth were used for sandblasting method with a microetcher device (ER/ERC-Danville Engineering INC, USA). With a tweezer, brackets were held in 5 mm distance from the etcher tip. The sand particles were aluminum oxide of 90 µm size (White Ortho Technology. Florida, USA) used for removing composite from bracket base under 90 PSI pressure, for the period of 15 to 30 seconds (Figs 3 and 4). (b) The rest 25 teeth and the bracket bases were etched with 37% phosphoric acid for 30 seconds and followed with bonding procedure. All brackets of both groups were debonded under Instron apparatus and SBS were recorded for samples.

RESULTS
According to the result of this study, the mean SBS in the control group was 172.11 kg force/cm\textsuperscript{2} with SD of 79.23 and standard error was 17.29. In the sandblasted group, the mean SBS value was 165.89 kg force/cm\textsuperscript{2} with SD of 69.55 and standard error was 24.59. Finally, in reconditioned group, the mean SBS value was 144.23 kg force/cm\textsuperscript{2} and SD of 83.80 and standard error was 27.93. The ranges of changes are also presented in Table 1.

The SBS values indicated that the strongest bonding occurs between bracket and fresh tooth at the first time. The reconditioned samples presented even weaker bonding strength in comparison with the sandblasted ones. However, the ANOVA analysis did not show any statistical difference amongst all three groups (p-value = 0.125). The related statistical values are presented in Table 2.

DISCUSSION
There are several possible methods of force application which can be used in bracket-debonding studies, including
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The mean value, standard deviation, standard error and range of values are presented

### Table 1: Shear bond strength of two different rebonding techniques are compared with control group

<table>
<thead>
<tr>
<th>Value group</th>
<th>Mean SBS</th>
<th>SD</th>
<th>Standard error</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>172.11</td>
<td>79.23</td>
<td>17.29</td>
<td>72.83-202.96</td>
</tr>
<tr>
<td>Sandblasted</td>
<td>165.89</td>
<td>69.55</td>
<td>24.59</td>
<td>113.97-199.25</td>
</tr>
<tr>
<td>Reconditioned</td>
<td>144.23</td>
<td>83.80</td>
<td>27.93</td>
<td>79.81-208.64</td>
</tr>
</tbody>
</table>

### Table 2: Index of one-way ANOVA analysis for different groups

<table>
<thead>
<tr>
<th>p-value</th>
<th>f-test</th>
<th>Square mean</th>
<th>Degree of freedom</th>
<th>Sum of squares</th>
<th>Value comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.125</td>
<td>2.209</td>
<td>13606.262</td>
<td>2</td>
<td>27212.254</td>
<td>Intergroups</td>
</tr>
<tr>
<td>—</td>
<td>—</td>
<td>6159.647</td>
<td>35</td>
<td>215587.63</td>
<td>Intragroups</td>
</tr>
<tr>
<td>—</td>
<td>—</td>
<td>—</td>
<td>37</td>
<td>242800.16</td>
<td>Total</td>
</tr>
</tbody>
</table>

A mode of force application can be used to model the effects of occlusal forces, which have been suggested to be important in bracket bond failure on posterior teeth.21

New brackets provide the strongest bonding with fresh teeth. Orderly, the sandblasted and reconditioned brackets make reasonable bonding strength to tooth. Nonetheless, these differences were not statistically significant (p-value = 0.125). The standard deviation was high in the re-etched group and low in sandblasted group. The wide range of SD value in reconditioned samples is indicative of unpredictability of this rebonding technique.

These bonding strength differences were in accordance with the result of Sonis22 and Tavares23 studies. In his study, Sonis22 used GAC brackets and light-cure composite. He found that SBS value was not statistically significant between control and sandblasted group.

Between two recycling techniques, aluminum oxide blasting method creates the highest bond strength.14,22 This better mechanical retention is evidently due to establishment of better microroughened surface of bracket base. The
smaller size of sand particles does not necessarily provide stronger bonding. Some other studies used the smaller particle, i.e. 50 μm size-instead of 90 μm and faced with weaker bond strength.\textsuperscript{2,24} The weaker bond strength is due to the less roughness (the more polished surface) created by smaller sand particles.\textsuperscript{3}

Millet et al\textsuperscript{13} found that sandblasting enhances bonding strength and, therefore, a recommendable procedure even for new brackets. He proposes 3 minutes’ exposure of blasting particles to new brackets base. Diedrich\textsuperscript{24} concluded with the same result and quantified the SBS increase of sandblasted new bracket up to 34%. Thus, this extra step benefits practitioners as well as patients for lessening bracket detachment occasions especially in low-compliant patients.

Regan et al\textsuperscript{25} found different results in their study, due to different method of bracket base preparation. After cleaning brackets with green stone, burning for 3 seconds, and sandblasting for 5 seconds, finally brackets were electro-polished. This resulted in 40% decrease of SBS value because of the loss of enough roughness for bonding. However, in other studies, the reconditioned bracket showed an acceptable SBS, due to the creation of reasonable roughness.\textsuperscript{26,27}

Several modifications were made in metallic brackets in order to reduce size and improve the bracket base because these variables influence the adhesion force directly.\textsuperscript{28} One of the modifications consists in pretreating the bracket bases, using different procedures: sandblasting, silanation, application of silica layer, microetching and application of adhesive systems.\textsuperscript{2,13,29}

Bracket breakage is a commonly encountered complication during routine orthodontic treatment. Success rates depend on the bonding agent employed, bonding technique used, etching time, concentration of the etch, or characteristics of the bracket base.\textsuperscript{1} Operator and patient factors are likely to influence the bond failure rate. Attention in the clinical technique, choice of proper bonding material, even slight contamination with saliva or lack of improper composite-primer application can lead to weaker bond strength between enamel and bracket and these factors are controlled by the operator. Gender and age of the patient, the presenting malocclusion, hard sticky diet during treatment, care taken of the appliance and generation of biofilm due to bad hygiene are patient variables.\textsuperscript{1,30-32}

Bond failures involving the enamel to resin interface are undesirable clinically as the risk of enamel damage when debonding may be increased. Failures that occur at the bracket to resin interface are much preferable in this regard.\textsuperscript{33} Another interesting issue is that Gursoy et al found that the use of recycled brackets results in significantly higher amounts of metal released into the artificial saliva.\textsuperscript{34} Several previous reports have documented different amount of chromium, manganese, copper and iron release for appliances made of new brackets and new archwires.\textsuperscript{35,36}

**CONCLUSION**

The shear bond strength of sandblasting and re-etching techniques is less than newly bonded brackets. Although this difference is a clinical fact, it was not recognized statistically significant. Between two rebonding methods, sandblasted brackets showed stronger bonding strength than re-etched ones.

**REFERENCES**

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