Evaluation and comparison of the shear bond strength of rebonded orthodontic brackets with air abrasion, flaming, and grinding techniques: An in vitro study

Hemant Kumar Halwai, BDS, MDS¹
Ranjit Haridas Kamble, BDS, MDS²
Pushpa Vinay Hazarey, BDS, MDS³
Vanita Gautam, BDS, MDS¹

Aim: To evaluate and compare in vitro the shear bond strength of rebonded orthodontic brackets among the three most frequently used rebonding methods—sandblasting, direct flaming, and grinding with a green stone bur. The surface characteristics of new and rebonded bracket bases were also compared using scanning electron microscopy (SEM). Methods: The sample used in the present study comprised 60 extracted human premolars bonded with brackets. The sample was divided into three groups (each n = 20; sandblasting, direct flaming, and grinding with a green stone bur). SEM was used to compare the surface characteristics of the new and rebonded bracket bases for all three groups. Results: The Z test for the direct flaming and grinding groups revealed statistically significant bond strength (P < .05). The ANOVA test for all three groups showed P < .05, which is statistically significant. SEM for the sandblasting method showed well-defined retentive areas. Conclusion: When rebonding brackets, sandblasting the bracket base yields the highest bond strength.


Key words: grinding and flaming, rebonding, sand blasting, shear bond strength

Bond failure of orthodontic brackets is common. Studies have shown that clinical bond failure still occurs in 5% to 7% of patients.¹ Most practitioners replace the dislodged bracket with a new bracket. This increases treatment costs. Rebonding the bracket can minimize treatment costs and eliminate the use of new brackets.

Rebonding is a procedure in which the debonded brackets are subjected to conditioning treatment whereby the bracket base area is cleaned and remnant adhesive removed. This procedure macro- and microscopically alters the structure of bonding surface, and a new surface area (mesh) is created for rebonding of the bracket to the tooth surface. The bonding strength of rebonded brackets is important to ensure successful treatment.
The major advantage of rebonding is economic savings, which could be as high as 90%, since a single bracket can be reused as many as five times. Other advantages include a smoother, more corrosion-resistant bracket after electropolishing and sterility as a result of the temperatures employed in the rebonding process. Disadvantages of rebonding include potential reduction in bracket quality, loss of identification marks, and increased risk of cross-infection.

There are several commercial rebonding methods available, all of which are impractical chairside. The two main commercially available methods for rebonding orthodontic brackets use a thermal or chemical method to remove the adhesive from the bracket base. The first method, relying on heat application, is the rebonding process created by Esmadent. The second method, by the Orthocycle company, employs chemical solvents. The disadvantages of commercial recycling methods, whether by heat or chemical means, leads to a degree of metal loss in certain areas of the bracket and a reduction in the diameter of the mesh strand. In addition, commercially rebonded brackets are more prone to corrosion, particularly brackets made from type-304 (AISI) stainless steel.

To overcome the delays associated with commercial rebonding methods, various chairside techniques have been developed. These include a variety of mechanical methods (eg, handpieces with rotary burs or green stone or chairside sandblasting) and thermal methods (the Buchman method, which consists of direct flaming to burn the composite off, followed by sandblasting and electropolishing).

Regan et al reported a 41% decrease in the bond strength of flamed brackets, which was equal to the decrease seen with brackets that had been roughened with only a green stone. Sonis reported that there is no significant difference in the shear bond strength of new and sandblasted brackets.

The objective of this study is to determine what method for bracket-base preparation yields the highest bond strength during rebonding. Various rebonding methods such as flaming, sandblasting, and green stone were compared.

**METHODS**

The present study was conducted in the Department of Orthodontics and Dentofacial Orthopedics, Sharad Pawar Dental College and Hospital, DMIMS, Wardha, India.

The samples comprised 60 healthy premolars extracted for orthodontic purposes and 60 MBT preadjusted edgewise premolar brackets (0.022-inch slots, Gemini Series, Unitek). Sample teeth were collected and stored in distilled water to prevent them from becoming brittle. The surfaces to be bonded were cleaned, rinsed, and thoroughly air dried. Etchant (3M Scotchbond) was applied to the tooth for 15 seconds, rinsed for 15 seconds, and dried for 2 seconds. A thin coat of primer (3M Transbond XT light-cured adhesive primer) was then applied, followed by adhesive to the bracket base of new brackets (control group), and light-cured adhesive interproximally for 10 seconds.

The samples were divided into three groups with 20 premolars in each group and were mounted in color-coded acrylic blocks to permit subsequent identifications.

- Orange blocks for rebonding of brackets, after sandblasting.
- Pink blocks for rebonding of brackets, after gas torch flame.
- Blue blocks for rebonding of brackets, after grinding.
Shear bond strength testing
A universal testing machine (no. 4467 H, Instron) was used to test shear bond strength. The specimen mounted in its acrylic block was secured to the lower grip of the machine (fixed head). To maintain a consistent debonding force, a custom-made blade was fixed in the upper grip (moveable head) connected to the load cell. The blade was positioned in such a way that it touched the bracket (Fig 1).

A crosshead speed of 1 mm/min was used. The computer recorded the force to debond the bracket in Newtons. The bond strength was calculated in MPa using the formula.

\[
\text{Bond strength MPa} = \frac{\text{Force in Newtons}}{\text{Surface area of brackets in mm}^2}
\]

The surface area of the bracket was 9.80 mm\(^2\) as given by the manufacturer.

Rebonding methods
Sandblasting method. Twenty brackets were sandblasted; 50 μm aluminum oxide abrasive powder was used. The distance between the bracket base and handpiece head was fixed at 10 mm. Each bracket base was sandblasted for 20 to 40 seconds under 80 psi (Fig 2).

Direct flame method. Twenty brackets were flamed. The flame tip of a gas torch was pointed at the bracket base for 3 seconds, during which the bonding agent started to ignite and burn off. The bracket was immediately immersed in room-temperature water, dried, and electropolished for 20 seconds and washed (Fig 3).

 Grinding/green stone method. Twenty brackets were rebonded by green stone burs on a contra-angled handpiece at slow speed for approximately 25 seconds (Fig 4).
After the brackets were reconditioned, each was bonded to the enamel surfaces that had been prepared for rebonding, using same method as for new brackets. The teeth were stored in distilled water for 72 hours before the brackets were debonded as described previously. Shear bond strengths were again recorded for each group.

A scanning electron microscope (SEM) was used to compare the surface characteristics of the new and rebonded bracket bases. Each specimen was prepared for SEM by sputtering with gold palladium in a Polaron E5100 sputter-coating unit. The bases of the brackets were then examined under an SEM (JEOL ISM 6380 A) operated at 10 KV at different 25× and 150× (Fig 5).

RESULTS

Statistical analysis was carried out using the Z and ANOVA tests. Table 1 shows the results of Z test for means, SDs, and standard errors (SEs) of the new and rebonded brackets. There is no difference in shear bond strengths between the control (new) and sandblasted brackets (Z = 0.39, \( P > .05 \)), which is not significant. The differences between the control (new) and direct flaming brackets and control (new) and green stone method brackets (Z = 3.80 and Z = 6.34, respectively; \( P < .05 \)) were statistically significant (Fig 6).
Table 1  Shear bond strength (MPa) of the new rebonded brackets

<table>
<thead>
<tr>
<th>Statistics</th>
<th>n</th>
<th>Mean ± SD</th>
<th>SEM</th>
<th>Z value</th>
<th>Critical value, Zα</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>New bracket</td>
<td>60</td>
<td>9.41 ± 2.78</td>
<td>0.35</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Sandblasting</td>
<td>20</td>
<td>9.12 ± 2.85</td>
<td>0.12</td>
<td>0.39</td>
<td>1.96</td>
<td>P &gt; .05</td>
</tr>
<tr>
<td>Direct flame</td>
<td>20</td>
<td>7.29 ± 1.91</td>
<td>0.42</td>
<td>3.8</td>
<td>1.96</td>
<td>P &lt; .05</td>
</tr>
<tr>
<td>Green stone</td>
<td>20</td>
<td>6.03 ± 1.76</td>
<td>0.39</td>
<td>6.34</td>
<td>1.96</td>
<td>P &lt; .05</td>
</tr>
</tbody>
</table>

SD, standard deviation; SEM, standard error of mean.

P < .05 was considered significant.

Table 2 shows the results of one-way ANOVA to evaluate the effect of re-bonding method on shear bond strength. There is significant variation in three groups (F = 9.46), which is statistically significant (P < .05). Thus, it is concluded that there is significant variation between the shear bond strength of sandblasting, direct flaming, and green stone methods.

SEM observations

Examination of the bases with scanning electron microscope at 25× and 150× magnification revealed that the new bracket (control group) had a smooth base with smooth surface with mesh and clear retentive areas in between the wire strands (Figs 7 and 8). Viewing the brackets under the SEM after rebonding showed variation of surface differences between the groups.

The sandblasted bracket bases were dull and rough, with intact multi-stranded structure, and the retentive areas were well-defined (Figs 9 and 10).

The flamed bracket bases showed that some of the retentive areas were filled with adhesive (Figs 11 and 12).
The green stone bracket bases showed that all available undercuts were filled with adhesive, and a slight grinding of the retention mesh was seen (Figs 13 and 14).
DISCUSSION

The main goal of the rebonding process is to completely remove the bonding material from the bracket base without damaging or weakening the delicate foil mesh or distorting the dimension of the bracket slot.

It has been shown that bonding between the bracket base and enamel surface must be strong enough to withstand stresses and shearing forces. Improper bonding technique, lack of mechanical retention of the bracket base, and heavy masticatory forces also contribute to the debonding of orthodontic bracket, which delays treatment and increases costs. Following the advent of direct bonding in the 1970s, techniques have been evolved for rebonding the orthodontic brackets so that they can be reused, thereby reducing the cost per case.

Bracket rebonding can be performed by the immediate method in the clinical practice or is performed by specialized companies. Two methods are commercially used in large scale: (1) heat applications for adhesive burning, followed by electrolytic polishing for removal of oxide and (2) use of chemical solvents for adhesive dissolution, combined with high frequency vibrations, and electrochemical polishing. These specialized companies are not available everywhere, and the methods are time consuming. However, several other methods for immediate chairside rebonding of debonded brackets have been evolved. These can be performed with sandblasting, direct flaming with electropolishing, or grinding with a green stone bur. These methods are easily carried out in the dental office with minimal cost.

Ideally, brackets should be easily bonded to the enamel, should not undergo any in-service bond failure and yet be easily removed at the end of treatment, without damage to the enamel surface. The highest number given as the clinically required optimal bond strength is 7.85 MPa.

The results in the present study show favorable bond strength in all rebonded brackets except the brackets rebonded by green stone method. The mean of the sandblasted brackets was 9.12 MPa, direct flaming brackets were 7.29 MPa, and with grinded brackets was 6.03 MPa.

The present study supports a previous study in which air abrasion was used to recondition debonded brackets, as were cut slots and welded mesh bases. The bracket was held approximately 5 mm from the tip of a microetcher and etched with 90 μm aluminum oxide at 90 PSI until all visible bonding material was removed from the bracket base. The results indicated no significant difference in shear bond strengths of new (17.14 MPa) and sandblasted brackets (16.77 MPa). The present study also shows that the mean shear bond strength of the rebonded brackets with green stone method (15.7 MPa) was significantly lower than all other methods—direct flaming (19.7 MPa) and sandblasting methods (21.5 MPa).

The findings of the present study also support another study, which found that the mean shear bond strength of the rebonded brackets with green stone method (15.7 MPa) was significantly lower than all other methods—direct flaming (19.7 MPa) and sandblasting methods (21.5 MPa).

The findings of Tavares and Consani are comparable with the present study findings—the shear bond strength of the rebonded brackets with the sandblasting method (0.34 kgf/mm²) was not statistically significant compared with the control brackets (0.52 kgf/mm²) and new brackets attached to previously bonded teeth (0.43 kgf/mm²). Brackets rebonded by the grinding method (silicon carbide stone) showed the lowest mean shear bond strength (0.14 kgf/mm²) and differed statistically from the control (new) brackets.

The findings of Wright and Powers are comparable with the present study. With the mean shear bond strength, values ranged from 1.07 kgf/mm² for initial bonding to 0.31 kgf/mm² when they were rebonded after removal of any residual adhesives with the green stone. Wright and Powers subjected the
brackets ( brazed mesh ) to be rebonded to a harsh treatment. The mesh base or any kind of base plays a major role in determining the bond strength of the bracket because the bond achieved between the enamel and bracket is through mechanical interlocking of the adhesive to resin tags produced in the enamel by virtue of acid etching and between bracket and resin surface by means of the characteristic base design. In any rebonding process, it is imperative to maintain the integrity of the surface design of the bracket base. By using green stone to either grind the adhesive from the base or grind off the mesh base itself, greater damage to the base results, which leaves no potential mechanical retention available for rebonding, resulting in a decrease in bond strength.

The findings of Wheeler and Ackerman ⁴ are comparable with the present study. They reported a 6% reduction in the bond strength of rebonded brackets compared with new bracket bond strength. On thermal rebonding, they found a decrease in bracket mesh diameter. A central portion of the base containing slight amounts of residue adhesive remnants suggests that the base pad was not completely free of debris. The present study supports the above findings.

The findings of Regan et al ⁶ are comparable with the findings of the present study. They compared the initial bond strength and rebonded strength of metal brackets (foil mesh and cast integrated base) with green stone and Bunsen flame. The initial bond strength of new brackets was significantly greater than that of rebonded brackets, Edgeway brackets, and Microlok brackets rebonded by green stone and Microlok brackets rebonded by Bunsen flame.

The foil mesh brackets prepared with green stone revealed a flat composite surface obliterating the entire mesh, thus eliminating virtually all mechanical retention. The brackets prepared by flaming, air abrasion, and electropolishing showed appreciable loss of metal structure from the foil mesh and also decreases the mechanical retention of the rebonded brackets.

The findings of Cau et al ¹³ are comparable with the findings of the present study. They found that the bond strengths of new and rebonded brackets with microetching (sandblasting) were equivalent.

However, the findings of Leas and Hondrum ¹⁴ are not comparable with the present study. They used foil mesh bases and found that rebonding strength was higher than the initial bond strength when treated with air abrasion alone (8.34%) or when air abrasion was used following flaming (11.02%).

The findings of the present study are also not comparable with the findings of Demas et al. ¹⁵ They compared the bond strength of rebonded brackets subjected to air abrasion for different timing—air abrasion for 3 seconds (15.45 MPa), 10 seconds (15.36 MPa), flame (10.20 MPa), Bunsen flame with air abrasion for 3 seconds (15.85 MPa), and brackets treated with green stone (12.36 MPa) and scaler (12.10 MPa). They found that the rebonded tensile and shear bond strength of all the brackets rebonded with the air-abrasion method were significantly greater than that of new brackets.

**CONCLUSION**

The findings of this study indicate that the shear bond strength of sandblasted brackets is significantly higher than flamed and ground brackets and that it is more time efficient and convenient than other methods.
REFERENCES