



## The Effect of Different Bracket Base Cleaning Method on Shear Bond Strength of Rebonded Brackets

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### ABSTRACT

**Aim:** To assess the effect of different bracket base conditioning method on shear bond strength (SBS) of rebonded brackets.

**Materials and methods:** Eighty brackets were bonded to freshly extracted premolar teeth using light cured composite adhesive. SBS was measured for 20 random samples as control group (G1). After debonding, 60 debonded brackets were allocated randomly into three groups of bracket base conditioning methods to remove the remaining adhesives. G2: bracket base cleaned with slow speed round carbide bur (CB), G3: cleaned with ultrasonic scaler (US), G4: cleaned with sandblasting (SB). After that, brackets were rebonded in the same manner as first bonding and SBS was measured. Modified adhesive remnant index (ARI) was recorded for all groups.

**Results:** SBS for new brackets was 11.95 MPa followed by 11.65 MPa for G2, 11.56 MPa for G4 and 11.04 MPa for G3 group. There were no statistically significant differences between all groups ( $p = 0.946$ ). In all groups, failure mode showed that the majority of adhesive composite remained on the bracket base with ARI of 4. There was no statistically significant difference between all groups in ARI ( $p = 0.584$ ).

**Conclusion:** In-office methods; slow speed CB and US are effective, quick and cheap methods for bracket base cleaning for rebonding.

**Keywords:** Laboratory study, Shear bond strength, Rebonded brackets.

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### INTRODUCTION

Orthodontic treatment involves the direct bonding of orthodontic brackets to the tooth surface. This bond must be strong enough to resist debonding forces during orthodontic treatment.

It has been suggested that bond strengths of 5.88 to 7.85 MPa are adequate for orthodontic bonding.<sup>1</sup> However, it is clear from the literature that a debonding rate of 4.7% for light cured and 6% for chemically cured adhesives are expected in the clinical practice for the first 6 months of treatment.<sup>2,3</sup> For economic reasons, some orthodontists prefer to reuse the debonded brackets. Several methods have been used to clean the bracket bases for rebonding; including sandblasting and sending the debonded brackets to specialist companies to remove excess adhesives from the bracket base for rebonding.<sup>4</sup>

Sending the brackets to specialist companies or to the laboratory, for bracket base reconditioning or sandblasting, means extra time, cost and the need for special instruments.

The aim of the current study therefore is to assess the shear bond strength (SBS) of brackets rebonded after cleaning the base with quick, simple and in-office procedures with no extra cost and time. These procedures are removal of remnant adhesives by tungsten carbide bur or ultrasonic scaler.

### MATERIALS AND METHODS

A total of 80 freshly extracted human maxillary premolar teeth were collected from patients for different reasons and stored in distilled water at room temperature. The buccal crown surface of each tooth was examined under 10× magnification to ensure that it was free of caries and restorations which might affect their resistance to experimental loading. Teeth were then divided into four groups of 20 teeth each and were bonded as the following:

*Group 1:* New bracket bonded to enamel surface of newly extracted teeth as a control group.

*Group 2:* Rebonded brackets, of which the base was cleaned by slow speed tungsten carbide bur, bonded to enamel surface of newly extracted teeth.

*Group 3:* Rebonded brackets, of which the base was cleaned by ultrasonic scaler, bonded to enamel surface of newly extracted teeth.

*Group 4:* Rebonded brackets, of which the base was cleaned by sandblasting, bonded to enamel surface of newly extracted teeth as a reference group for groups 2 and 3.

### Bracket Base Preparation

Sixty debonded intact premolar brackets (Omni 0.022" Roth, GAC International Inc, New York, USA) were randomly allocated to one of bracket's base cleaning method (20 brackets each) as following:

*Method 1:* Base was cleaned and adhesive was removed with slow speed round tungsten carbide bur (Jota CIS FG 023 round tungsten carbide US-No. 8S, Swiss Precision, Switzerland).

*Method 2:* Base was cleaned and adhesive was removed with ultrasonic scaler (Sirona Sonic L, 25-32 KHz).

*Method 3:* Base was cleaned and adhesive was removed with sandblasting (CoJet™ System Set; 3M Espe).

The average time, to the nearest second needed to remove adhesive from a single bracket base, was recorded for methods 1 and 2.

In order to evaluate the adhesive cleaning method, a random bracket was selected from each group and its base was examined under scanning electron microscopy (SEM) (FEI, Quanta 200 SEM, Göteborg, Sweden) and compared with a new bracket.

### Bonding

The 80 teeth were divided into four groups each counting 20 teeth. Each tooth was mounted in cold curing, fast setting acrylic (Leocryl; Leone, Sesto Fiorentino, Italy). The teeth were aligned so that their buccal surfaces were exposed and parallel to the force during shear bond testing. Each tooth was given a number to ease identification. The buccal surface of each tooth was etched with 37% orthophosphoric acid gel (3M Espe) for 30 seconds. Each tooth was then rinsed thoroughly with water spray for 15 seconds and dried with oil-free compressed air until the etched surface exhibited a frosty white appearance with no traces of moisture. Transbond XT primer (Transbond™ XT Adhesive, 3M Ltd, Monrovia, California, USA) was applied on the etched surface in a thin film and light cured with a curing light (Biolux™, CFON 1163, BIO-ART Dental Equipment Ltd, Sao Carlos, Brazil) for 10 seconds according to manufacturer instructions. Subsequently, the adhesive was applied to the base of preadjusted edgewise metal orthodontic bracket (Omni 0.022" Roth, GAC International Inc., New York,

USA), both the new (G1) and the newly debonded and cleaned brackets (G2, G3 and G4). Brackets were positioned and pressed firmly onto the tooth using a dental explorer. The excess adhesive was removed from around the bracket base with an explorer and then the adhesive was cured with curing light (Biolux™, CFON 1163, BIO-ART Dental Equipment Ltd, Sao Carlos, Brazil) which was applied on the mesial and distal sides of the bracket for 10 seconds each as recommended by the manufacturer.

After bonding, all specimens were thermocycled from 5°C to 55°C and back to 5°C 500 times. The dwell time at each temperature level was 30 seconds and the transfer time between baths was 10 seconds. Subsequently, they were stored in distilled water at 37°C for 24 hours prior to testing. All bonding and thermocycling procedures were done by the same operator (SA).

To prevent deformation of the bracket during testing, a 1 cm long 0.019" × 0.025" rectangular stainless steel archwire (TrueForce™ Stainless Steel Archwire, Ortho Technology®, Florida, USA) was ligated into the orthodontic bracket slot using elastomeric ligature (Power Sticks™ Elastomeric Ligature, Ortho Technology®, Florida, USA).

The SBS testing was performed using a computer control electromechanical universal testing machine (WDW-20, JINAN testing Equipment I E Corporation, China) at the solid Material Testing Laboratory, Department of Mechanical Engineering, Jordan University of Science and Technology. The specimens were clamped vertically in the testing machine so that the bracket base was parallel to the direction of the shear force. A thin ligature wire loop (0.030", TruForce™ Stainless Steel Preformed Ligature Ties, Ortho Technology®, Florida, USA) was placed under the gingival wings of the bracket to apply the debonding force in a gingivo-occlusal direction by movement of the crosshead of the testing machine at a speed of 1 mm/min. The force required to debond the brackets was recorded in Newton.

The projected bonding surface area of the premolar bracket was calculated using Baty shadoMaster machine (Type R11M, Number s3896, J.E.BATY & Co Ltd., Victoria road, West Sussex). The surface area of the premolar bracket was 10.66 mm<sup>2</sup>. Subsequently the SBS in MegaPascal was calculated by dividing the force in Newton over the projected surface area in mm<sup>2</sup>.

### Mode of Bond Failure

The bracket bases and the bonding areas of the teeth were inspected visually by the SA using a magnifier with 88 mm diameter lens and 2.5× magnification (Number: G-777-090, Shenzhen Guanyida Optical Production Corp, Ltd, China) to

determine the amount of adhesive resin left on the enamel surfaces according to the modified adhesive remnant index (ARI).<sup>5,6</sup> The ARI scale ranges from 1 to 5 as the following:

*Score 1:* The entire composite remained on the tooth with distinct impression of the bracket base.

*Score 2:* More than 90% of the composite remained.

*Score 3:* More than 10% but less than 90% of the composite remained.

*Score 4:* Less than 10% of composite remained on the surface.

*Score 5:* No composite remained on the enamel.

A random bracket was selected from each group and its base was examined under SEM (FEI, Quanta 200 SEM, Göteborg, Sweden) to evaluate the mode of failure.

**Method Error**

Twenty randomly selected teeth were re-examined by the same examiner (SA) after a period of 1 week, and the kappa test was applied to test intraexaminer reliability for ARI scores. Kappa values were above 92%.

**Statistical Analysis**

Statistical analysis was performed using the statistical package for social science (SPSS) computer software (SPSS 20.0, SPSS Inc., Chicago, USA). Descriptive statistics (means, standard deviation and 95% confidence interval) were calculated for SBS of all groups. The differences between the four groups were analyzed using the one-way analysis of variance (ANOVA). The differences between ARI were analyzed using Chi-square test. Significance was predetermined at 0.05 levels.

**RESULTS**

The mean time needed to clean the bracket base with round carbide bur was 32 seconds whereas that needed with ultrasonic scaler was 97 seconds ( $p < 0.001$ ).

**SBS**

The mean, standard deviation (SD) and 95% confidence interval (CI) of SBS of different groups studied are shown in Table 1. No significant differences were found between the different groups ( $p > 0.05$ ) (Table 2).

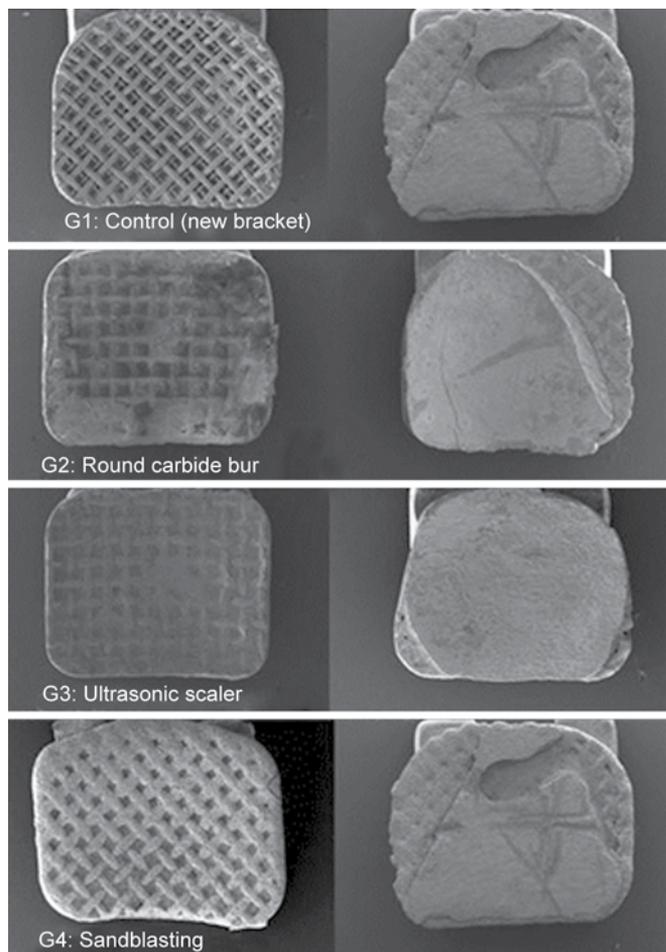
Groups	Mean (MPa) ± SD	95% CI	
		Lower bound	Upper bound
1	11.95 ± 3.93	9.77	14.12
2	11.65 ± 3.79	9.55	13.75
3	11.04 ± 4.11	8.76	13.31
4	11.56 ± 4.78	8.91	14.21

	Sum of squares	df	Mean square	F	Significance p-value
Between groups	6.42	3	2.14	0.123	0.946
Within groups	973.86	56	17.39	–	–
Total	980.29	59			

Groups	ARI					Chi-square p-value
	1	2	3	4	5	
1	2	4	6	6	2	0.584
2	1	3	3	9	4	
3	2	3	5	6	4	
4	4	3	5	5	3	

**Adhesive Residual Index**

The ARI scores for the four groups tested are shown in Table 3. No significant differences between the groups ( $p > 0.05$ ) were detected. No significant correlation was found between SBS values and ARI scores. SEM of the bracket bases of the different tested groups are shown in Figure 1. SEM appearance of bracket base in all groups shows more adhesive composite remaining on bracket base.



**Fig. 1:** SEM of the bracket bases of the different tested groups before bond up and after debond

## DISCUSSION

Detachment of brackets during the course of orthodontic treatment requires bonding new brackets or rebonding the detached ones. For reason of economy, orthodontists prefer to rebond the debonded brackets.<sup>4</sup> Rebonding of used brackets requires removal of adhesive composite from the bracket base. Several bracket base conditioning methods have been investigated. Sandblasting of the bracket base has been found effective and resulted in a comparable SBS to the new brackets.<sup>7</sup> Reconditioning of the bracket base by specialist companies has also been found effective and produced adequate SBS.<sup>4</sup> However; these methods may require time and special instruments, therefore this study aimed at assessing the SBS of debonded brackets conditioned by quick, cheap and simple in-office methods alongside the sandblasting method. In the present study, each group composed of 20 teeth as recommended by Fox et al<sup>8</sup> who suggested that at least 20 specimens should be used per test if valid conclusions are to be withdrawn from *in vitro* bond strength testing. The specimens in the present study were thermocycled from 5°C to 55°C and back for 500 cycles to stimulate the temperature fluctuation present in the oral cavity.<sup>9</sup>

In this study, two in-office available methods; adhesive removal with slow speed round carbide bur and with ultrasonic scaler, were tested. No significant differences were found between the different groups. The mean SBS of the reused brackets were comparable to that of new brackets. Of the reused brackets, those cleaned by carbide bur showed the greatest bond strength while those cleaned by ultrasonic scaler showed the lowest. However, no significant differences were found between the different cleaning methods and the SBS for each group exceeded the minimum recommended value of 5 to 8 MPa.<sup>1</sup> Although the difference in the time needed to clean the brackets in office is statistically significant, clinically it is not.

In this study, sandblasting resulted in a comparable SBS to that of new brackets. This was in agreement with that reported by Sonis.<sup>7</sup> The SBS of rebonded brackets conditioned by slow speed carbide bur was also comparable to that of new brackets. This disagrees with that reported by Basudan and Al-Emran<sup>10</sup> who used green stone to grind the bracket base and reported a significantly less SBS compared to new brackets. In this study, round carbide bur was used to remove the adhesive composite from the bracket base, which may result in a more effective removal than green stone. This may be because green stone grinds the composite from the outer layer until it reaches the metal base and start grinding it leaving less retentive features, whereas carbide bur will,

in addition to the grinding from the outer layer, break the junction between composite and the bracket base and leaves more retentive features of the metal base. Ultrasonic scaler as a reconditioning method was tested and found effective and resulted in a comparable SBS to that reported for new brackets. No previous studies have tested ultrasonic scaler as a conditioning method of rebonded brackets. Ultrasonic scaler also breaks the junction between the adhesive composite and bracket base and removes it leaving the retentive features of the bracket base for the second bonding.

## CONCLUSION

SBS of rebonded brackets cleaned with slow speed round carbide bur, ultrasonic scaler and sandblasting was comparable to that of new brackets.

In office available methods; slow speed carbide bur and ultrasonic scaler are effective, quick and easily available methods for bracket base cleaning for rebonding.

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