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Influence of Two Different Bracket Base Cleaning Procedures on Shear Bond Strength Reliability

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ABSTRACT

Purpose: To search if the shear bond strengths of brackets would change after two different base-cleaning procedures such as sandblasting or carbide bur cleaning, and to determine if a previously bonded tooth surface had any effect on bond strength.

Materials and methods: A total of 120 new brackets were first bonded to 120 extracted premolars and then debonded and bond strength was recorded. The debonded brackets were divided into two groups and recycled either by sandblasting or tungsten-carbide bur cleaning. Sixty recycled brackets were divided into two subgroups: In each group; 30 recycled brackets were bonded to unused 30 extracted premolars. The remaining brackets were bonded to 30 previously used premolars. The brackets were debonded again and their bond strengths were remeasured.

Results: Bond strength of rebonded brackets after sandblasting was not significantly different from that of new brackets while the bond strength of rebonded brackets after carbide bur cleaning group significantly decreased. The previously bonded tooth surface did not affect the bond strength significantly.

Clinical significance: This study showed that rebonding the brackets after sandblasting supplies sufficient bond strength. Previously bonded tooth surface did not cause a decreasing effect on bond strength. However, when carbide bur cleaning procedure is chosen, the clinician should proceed cautiously.

Keywords: Bracket base cleaning, Shear bond strength, Recycling, Sandblasting, Carbide bur, Laboratory research.

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INTRODUCTION

The need for rebonding has resulted from the bond failure. One of the controversies that clinicians face with the bond failure is to decide if rebonding the same bracket would provide a sufficient bonding or a new bracket should be preferred. There are several commercial recycling methods available,[1,2] but these are impractical to perform at the chairside. As a result, several in-office bracket recycling methods have been introduced.[3-5] It has been found that the tensile bond strengths of the reused brackets were significantly lower than new brackets *in vitro* when a green stone was used to remove the surface layer of the residual resin on the bracket base.[3,4] Heating in flame was also found to decrease the bond strength dramatically.[3,5] On the contrary, when sandblasting techniques were evaluated,[6-9] it was found that sandblasting could increase the bond strength. Furthermore, Quick et al[5] tried to find a rapid office method of recycling brackets and found that sandblasting provided the simplest, most efficient way.

The cause of failures could be the alteration of enamel that follows previous bonding procedures.[10] Mizrahi[11] found that when the attachments were replaced second time and third time, the failure rate rose from 4 to 14 and 25% respectively. Bishara et al[12] stated that the changes in bond strength after repeated bonding may be related to changes in the morphologic characteristics of the tooth surface caused by adhesive remnants. In a recent study,[13] it has been shown that repeated bonding and debonding procedures did not lead to a decrease in shear bond strength.

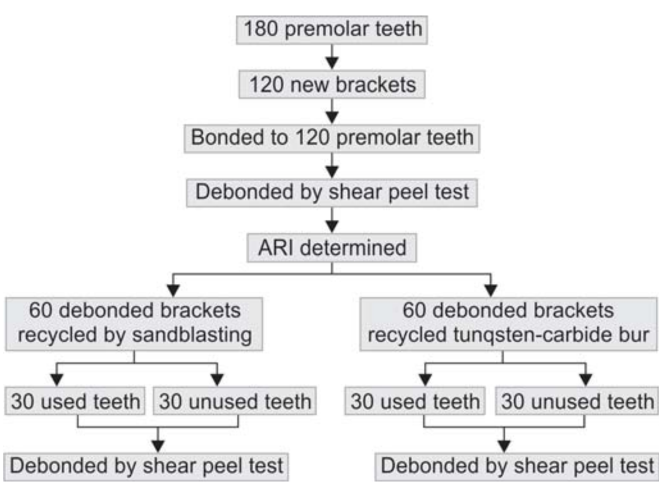
In terms of reusing the brackets, most studies have focused on the bond strengths of the brackets, however; there is limited data available about the bond strengths of the brackets bonded to reprepared tooth after failure.[9,11-13] The aims of this study were (1) to compare the changes in shear bond strengths of brackets recycled either by sandblasting or by tungsten-carbide bur cleaning, (2) to determine if a reprepared tooth surface had any effect on bond strength of the rebonded brackets.

MATERIALS AND METHODS

One hundred and twenty new metal premolar brackets (GAC International, Bohemia, NY) with 12.13 mm^2 bracket base surface area and 180 extracted human maxillary and mandibular premolars with intact buccal enamel surfaces were used in this study. The teeth were stored in 1% solution of chloramine. Each tooth was embedded in chemically activated acrylic resin, leaving only the crowns exposed. The buccal surfaces were cleaned with pumice at slow speed for 15 seconds by using a brush and the samples were stored in an airtight humid environment to prevent dehydration.

From all of the teeth, 120 were selected randomly for the first stage (Flow Chart 1). The remaining 60 extracted premolars were kept for the second stage of the study. The buccal surfaces of the selected teeth were etched with 37% phosphoric acid gel for 30 seconds and washed with water for 20 seconds. After drying with compressed air for 20 seconds, orthodontic brackets were bonded to the teeth with Light Bond Sealant™ and Quick Cure™ adhesive (Reliance Ortho Products Inc, Itasca, Illinois, USA) according to the manufacturer's instructions. An Instron universal testing machine was used for the shear bond test at a crosshead speed of 1 mm/min. Force was applied to the bracket–tooth interface by a flattened steel rod. The load at the bracket failure was recorded and the shear bond strength values were calculated in MegaPascals by dividing the force to the area of the bracket base. The bracket bases were examined with 25× magnification by an optical microscope (OPMI® pico/S100, Carl Zeiss Surgical, Inc, Germany). Any adhesive that remained on the bracket was assessed according to adhesive remnant index (ARI) and scored.[14] The ARI scale has a range of 0 to 3 (0 = no adhesive left on the bracket, 1 = less than half of the adhesive left on the bracket, 2 = more than half of the adhesive left on the bracket, 3 = all adhesive left on the bracket). The debonded brackets were divided into two groups; (1) recycled by sandblasting with 90 µm aluminum oxide (n = 60), (2) cleaned by tungsten-carbide bur (#118S, Reliance Ortho Products Inc, Itasca, Illinois, USA). The removal of the composite was considered complete when no adhesive was seen to the naked eye.

Flow Chart 1: Illustrating the methods used



Of the 120 used teeth, 60 of them were selected randomly for the second stage. The adhesive was removed from the previously bonded enamel surface with a high-speed tungsten-carbide bur until the tooth surface seemed smooth and free of composite to the naked eye. Sixty used and cleaned by tungsten-carbide bur teeth were divided into two subgroups. In each subgroup; 30 recycled brackets via sandblasting and tungsten-carbide bur were bonded to unused teeth. The remaining brackets were bonded to 30 used teeth. The brackets were debonded again and their bond strengths were remeasured.

Descriptive statistics, including the mean, standard deviation were calculated for each of the three groups. The univariate ANOVA was carried out to analyze the effect of recycling methods and the tooth surface properties on mean shear bond strength. Test of between subject effects was conducted in order to determine the interaction between the recycling method and the reprepared tooth surface. Pairwise multiple comparisons between the groups were performed by one-way ANOVA and Turkey test to determine whether a significant difference occurred between the groups.

RESULTS

The mean shear bond strength of the new brackets was 9.6 ± 2.7 MPa (Table 1). The brackets recycled by sandblasting had the highest mean shear bond strength (10.8 ± 2.9 and 10.8 ± 2.6 MPa for new and used teeth respectively) while the new brackets bonded to unused teeth had lower shear bond strength than sandblasted group. The brackets recycled by tungsten-carbide bur cleaning had the lowest shear bond strength; 6.7 ± 1.6 MPa for unused teeth and 7.6 ± 2.3 MPa for used teeth respectively when compared with new and sandblasted brackets. When rebonded to unused teeth, shear bond strength of the brackets recycled by carbide bur were lower than that of used teeth. Data analysis revealed that there were differences in shear bond strengths between some of the groups (Table 2). Sandblasting did not change the shear bond strength, while tungsten-carbide bur cleaning diminished the bonding strength significantly ($p \leq 0.05$) when compared with the new brackets bonded to unused teeth. Rebonding the sandblasted brackets to either unused or used teeth did not make any significant difference on bond strength. However; tungsten-carbide bur cleaning, regardless of the type of teeth, had a significant decrease in bond strength when compared with sandblasting. On the

Table 1: Bond strengths (MPa) of the new brackets and recycled bracket groups

Groups	*n*	*Mean*	*SD*
New brackets—unused teeth	120	9.6	2.7
Brackets recycled by sandblasting—unused teeth	30	10.8	2.9
Brackets recycled by sandblasting—used teeth	30	10.8	2.6
Brackets recycled by carbide bur—unused teeth	30	6.7	1.6
Brackets recycled by carbide bur—used teeth	30	7.6	2.3

SD: Standard deviation.

Table 2: Multiple comparisons of shear bond strengths (MPa) of all groups

Groups				*Sig.*
New brackets—unused teeth	9.6 ± 2.7	Sandblasted—unused teeth	10.8 ± 2.9	NS
		Sandblasted—used teeth	10.8 ± 2.6	NS
		Carbide bur—unused teeth	6.7 ± 1.6	*
		Carbide bur—used teeth	7.6 ± 2.3	*
Sandblasted—unused teeth	10.8 ± 2.9	Sandblasted—used teeth	10.8 ± 2.6	NS
		Carbide bur—unused teeth	6.7 ± 1.6	*
		Carbide bur—used teeth	7.6 ± 2.3	*
Sandblasted—used teeth	10.8 ± 2.6	Carbide bur—unused teeth	6.7 ± 1.6	*
		Carbide bur—used teeth	7.6 ± 2.3	*
Carbide bur—unused teeth	6.7 ± 1.6	Carbide bur—used teeth	7.6 ± 2.3	NS

*$p \leq 0.05$; NS: Nonsignificant

other hand, to use unused or used teeth after carbide bur cleaning did not affect the bond strength significantly as seen in the sandblasting group (Table 3).

Scoring the amount of adhesive remaining on the base of the brackets after debonding indicated that in the majority of the cases, the amount of adhesive on the base was in score 1 (Table 4).

DISCUSSION

The objectives of this study were to evaluate the bond strength of rebonded brackets cleaned either by sandblasting or tungsten-carbide bur and to determine if a reprepared tooth surface had any effect on bond strength. A variety of reconditioning techniques, including the use of a green stone or carbide bur in a slow handpiece, a periodontal scaler, sandblasting and thermocycling has been reported.[6,15-19]

Table 3: Test of between subjects effects, between the recycling method and the reprepared tooth surface

	Sig.
Recycling method—	*
type of teeth	NS
Recycling method—type of teeth	NS

*$p \leq 0.05$; NS: Nonsignificant

Although tungsten-carbide bur is very common in use in the orthodontic practice;[20] recycling of a bracket base with tungsten-carbide bur with a high speed handpiece has not been reported. As it serves the practitioner the easiest and the rapid way of removal of the resin at the chairside, it was thought to be of clinical value, as long as the adequate shear bond strength was maintained.

Bond strength can vary depending on the method of testing.[21] Because most of the studies evaluated the shear bond strength, shear type of load was chosen as a testing method in this study in order to validate the results when compared with the other studies. The rate of force application is one of the parameters that shows large variety

Table 4: Frequency distribution of ARI scores

ARI scores	*0*	*1*	*2*	*3*
New brackets—unused teeth (n = 120)	3	78	18	21
(%)	2.5%	65%	15%	17.5%
Brackets recycled by sandblasting—unused teeth (n = 30)	1	20	3	6
(%)	3.3%	66.7%	10%	20%
Brackets recycled by sandblasting—used teeth (n = 30)	2	25	1	2
(%)	6.7%	83.3%	3.3%	6.7%
Brackets recycled by carbide bur—unused teeth (n = 30)	8	21	0	1
(%)	26.7%	70%	0	3.3%
Brackets recycled by carbide bur—used teeth (n = 30)	3	27	0	0
(%)	10%	90%	0	0

ARI scores: Adhesive remnant index scores; 0: No adhesive left on the bracket; 1: Less than half of the adhesive left on the bracket; 2: More than half of the adhesive left on the bracket; 3: all adhesive left on the bracket in shear bond testing. Klocke and Kahl-Nieke[22] have shown that the variations in crosshead speed between 0.1 and 5 mm/min do not have a significant influence on debonding forces. In this study, crosshead speed of 1 mm/min was applied during testing.

This study was conducted with 30 specimens in each group. In the literature many studies, including less number of specimens were reported regarding the bond strength. However, it has been suggested that at least 20 preferably 30 specimens per experimental group should be utilized[23] since bond strength data may not follow a normal distribution[24] and abnormal distribution of data is likely to be found in the sample sizes of less than 10 specimens in each group.[25] In order to eliminate the bias that may occur in minds due to the sample size, the number of specimens kept maximum so that reliable results can be obtained.

Bond strengths between 8 and 9 MPa are sufficient to withstand normal orthodontic forces.[26] The maximum bond strength should be less than the breaking strength of the enamel, which is about 14 MPa.[27,28] The results of this study showed that recycling by sandblasting provided the highest mean bond strength than new brackets and recycling by tungsten-carbide bur. It is interesting to find out that sandblasting increased the retention of the brackets even when compared with new brackets. Sandblasting not only removes the remaining adhesive but it might also roughen the metal surface, increasing the micromechanical undercuts to allow better bonding. In one study, it was shown that sandblasted brackets could be reliably rebonded, and the damage to the bracket base caused by sandblasting was minimal, and the shear bond strength was not compromised.[29] However, Regan et al[3] found that rebonding the previously used brackets which had been prepared by sandblasting resulted in a significant decrease in bond strength. In contrast with the results of sandblasting technique in this study, tungsten-carbide bur led to a significant decrease in shear bond strength. The ARI scores showed that most of the failures occurred at the base-adhesive interface. The differences in shear bond strength between the groups are probably due to the abrasion of the retention mesh base as well as the incomplete removal of the composite resin. Regarding the tungsten-carbide bur, the result of this study showed that even if a cleaning procedure is done till a naked eye can not see any remnant, invisible resin can still stay on the base and grinding method can wear the mesh surface, leading to a loss of retention when the bracket is rebonded. The shear bond strength was not as low as the reported minimum value of the tensile strength. However, when a decision is made on using tungsten-carbide bur, it should be kept in mind that an insufficient retention may cause rupture of the bracket and an adhesion booster might be needed to enhance the bond strength.[30]

It has been reported that rebonded teeth had significantly lower bond strength which might be related to the changes in morphologic characteristics of the enamel surface caused by remnants. Although not visible to the naked eye, it was shown that the remnants decreased the overall roughness of the enamel even after the removal of the adhesive totally.[12] Our study did not confirm the decrease occurring after repeated bonding. This might be due to that reason: Removal of the adhesive from the tooth surface by tungsten-carbide burs may provide the smoothest enamel surface, very similar to untreated enamel.[31] On the contrary, Montasser at al[13] suggested that increase in bond strength after repeated bonding might be due to the presence of residual adhesive, which could lead to mechanical or chemical retention. Regan et al[3] emphasized that the reduction in repeated bonding was not considered sufficient to be important clinically since the brackets had still adequate bond strength.

Extrapolation of laboratory data to the clinical situation should always be done with caution. However, this study shows that recycling brackets can be of benefit both ecologically and economically as long as the orthodontist is aware of aspects of the recycling methods.

CONCLUSION

1. Rebonded brackets after sandblasting has the highest shear bond strength when compared with unused teeth-new bracket bonding and tungsten-carbide bur cleaning.
2. Tungsten-carbide bur cleaning alone leads to a significant decrease in shear bond strength.
3. In case of repeated bonding, previously bonded tooth surface did not affect the shear bond strength of rebonded brackets.

CLINICAL SIGNIFICANCE

This study showed that rebonding the brackets after sandblasting supplies sufficient bond strength. Previously bonded tooth surface did not cause a decreasing effect on bond strength. However, when carbide bur cleaning procedure is chosen, the clinician should proceed cautiously.

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