

Comparison of Two Different Orthodontic Bracket Recycling Techniques

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ABSTRACT

Introduction: The cost of orthodontic treatment in most of the industrialized countries may considerably differ from those in third world countries. The lesser cost of orthodontic treatment, high pricing of orthodontic inventory and poor economic conditions of the people strengthen the notion of 'recycling' even more.

Objectives: To compare the shear bond strengths of .022 slot pre-adjusted edgewise brackets with conventional mesh base design recycled by two different chair-side techniques, one being flaming/heating and other being sandblasting.

Materials & Method: The sample involved eighty extracted human premolars with .022 slot pre-adjusted edgewise brackets (Orcmo, USA) bonded onto the lingual surface. After initial de-bonding the bracket base was studied under a scanning electron microscope at different magnifications for aperture size, mesh continuity and surface roughness. The brackets were re-bonded on to the labial surface of the same premolars and then debonded using a Universal Testing Machine to produce a shear force at the tooth bracket interface.

Result: The study showed highest bond strengths with the control group (111.52 ± 49.90 N) and least bond strengths with the heating/flaming group (63.71 ± 22.43 N). Reduced aperture dimensions and loss of mesh continuity were characteristics of the Heating group. Sand Blasting showed significantly higher bond strengths (100.42 ± 39.42 N) with considerably rougher mesh surface texture compared to heating group.

Conclusion: Sand blasting as a mode to reconditioned orthodontic bracket base provides a higher shear bond strength compared to orthodontic brackets reconditioned by heating/ flaming ($p < .01$).

Keywords: bracket recycling, heating, sandblasting, shear bond strength

INTRODUCTION

In order to improve bond strength, the bracket base has evolved over the years from the primitive perforated metal base to the widely known foil mesh, to more advanced laser structured base retention brackets, and plasma coated metal bracket bases.¹ Although adequate result with mesh base advancements may be obtained in clinical practice, failures do occur. "Accidental dislodgement of an orthodontic bracket due to occlusal trauma or intentional removal of a bracket in order to reposition it to achieve ideal occlusal goals is common occurrences in orthodontic treatment."²

One solution was to recycle orthodontic brackets.³ The cost of orthodontic treatment in most of the industrialized countries may considerably differ from those in the third world countries. The lesser cost of orthodontic treatment, high cost of orthodontic inventory and poor economic

conditions of the people makes it convenient to recycle orthodontic brackets and save expenses instead of replacing them with a new one. The orthodontist must know the best method to recycle/recondition the used bracket in order to save the patient from paying for the new bracket and at the same time saving the cost on the inventory.

The aim of any bracket recycling system is to remove the adhesive residue from the bracket base completely without causing structural damage, in order to eliminate all impurities related to orthodontic treatment, so that the bracket can be rebonded to the enamel surface producing a new adhesive bond of adequate strength.^{4,7}

According to Tavares *et al*,⁸ the methods of recycling brackets may be classified as Industrial (chemical and heating) and chair-side use of a tungsten carbide bur, heating and sandblasting.

The chair-side procedure most commonly involved heating the bracket base till it turned crimson red. Heat was used for primer removal and sterilization.⁹ It was only between 420° and 500° Celsius that composites were transformed into white powder and could be easily removed.

Another technique very commonly used for recycling is air abrasive technique or sand blasting. It has been used extensively in restorative dentistry to enhance the mechanical adhesion between metal and adhesive resin.¹⁰⁻¹²

The present study aims to compare the shear bond strength of .022 slot pre-adjusted edgewise bracket with conventional foil mesh base design recycled by two different chair-side techniques, one being flaming/heating and the other being sandblasting.

MATERIALS AND METHOD

The sample of this study involved eighty extracted human upper and lower premolars. Teeth that had been extracted for more than 3 months or those that had been bonded with brackets before and those with caries or restorations, cracks and fractures caused by the use of extraction forceps were excluded from the study.

The samples were divided into three groups; Group A (Heated/Flamed Brackets), Group B (Sandblasted Brackets) containing thirty teeth each, and Group C (Control group) containing twenty teeth. Each tooth was mounted vertically in cold self-cured acrylic blocks. The teeth were cleaned and stored in normal saline solution (NSS).

The surface of each tooth crown was cleansed with a mixture of water and fluoride-free pumice in a rubber prophylactic cup for 10 seconds. Each tooth was then rinsed with water spray for 10 seconds and dried with an oil-free air drier. The enamel surface was etched with 37% phosphoric acid gel (Ormco, USA) for 15 seconds, and the tooth was thoroughly rinsed and dried. A thin uniform layer of Ortho Solo primer (Kerr, USA) was applied to the etched enamel surface, and Enlight adhesive (Ormco, USA) was applied to the bracket base. The bracket (Mini 2000 series pre-adjusted edgewise brackets, .022 slot, Ormco, USA) was placed onto the lingual surface of the tooth and was pressed firmly into place to express adhesive from the margins of the bracket base.

Excess adhesive was removed with an explorer before curing. Then, the bracket was light-cured with an light-emitting diode (LED) curing light for 20 seconds: 5 seconds mesially, 5 seconds distally, 5 seconds buccally and 5 seconds lingually / palatally.¹³⁻¹⁶

After the bonding procedure, the samples were stored in NSS at 37°C for 24 hours. The samples underwent thermo cycling in two thermally controlled water containers maintained at 15°C and 75°C with a dwell time of 10 minutes for thirty cycles. The heater was turned off to maintain no thermal variance inside the container. This was done to simulate the thermal variance of the oral cavity during eating and drinking hot and cold food and drinks. After thermo-cycling, the samples were stored in NSS at 37°C for 24 hours.

For initial debonding, a rectangular wire was passed through the bracket slot and tied loosely with metal ligatures. Then the wire was pulled in an occluso-gingival direction to debond the brackets from the tooth surface. Sixty samples were debonded by the above mentioned method. The remaining twenty were kept as the control. After debonding of the brackets, the brackets were divided into two groups of thirty brackets each randomly. Group A were the brackets recycled by heating or flaming and Group B were the ones sandblasted.

Following the debonding, the teeth and brackets were examined under a magnifying glass to analyze the bonded enamel surfaces and bracket bases. The Adhesive Remnant Index (ARI)¹⁷ was used to classify the failure patterns that were observed in bonded specimens with the following criteria for scoring:

- Score 0- No adhesive left on the tooth
- Score 1 - Less than half of the adhesive left on the tooth
- Score 2 - More than half of the adhesive left on the tooth
- Score 3 - The entire adhesive left on the tooth with distinct impression of the bracket mesh

Out of sixty debonded teeth; seven had a Score 0, thirty two had Score 1 and twenty one had Score 2.

For Group A, the flame tip of the hydro solder torch was pointed at the bracket base during which the bracket turned to "crimson red" and the adhesive residue started to ignite and burn out. Then the brackets were cooled at room temperature and dried in an air stream. The adhesive residue after the procedure was not scrapped off the bracket base as it would alter the mesh properties.

For Group B, each bracket base was sandblasted using Shofu HiBlaster pencil type sand blaster (alumina particles 50 microns) at a distance of 10 mm under 9 bars of pressure until all visible adhesive residues were removed.

From each group, seven brackets were chosen randomly and studied under the Scanning Electron Microscope (SEM) (JEOL JSM-5310) from a magnification of 15X up to 350X. Following aspects were studied to validate the results of the shear bond strengths in the study:

Table 1: Measures of Shear Bond Strength of two different bracket reconditioning methods with Control

Shear Bond Strength	n	M (N)	SD
Heating/ Flaming (A)	28	63.71	22.43
Sandblasting (B)	28	100.42	39.42
Control (C)	20	111.52	49.90

n, Number of samples; M, Mean Shear bond strength (Newtons); SD, Standard deviation

- The Aperture size
- Mesh continuity
- Surface roughness

The brackets were then re-bonded on to the labial surface of the same sixty premolars. After this the exact same bonding procedure was repeated with the thermo-cycling process for the labial surface of sixty premolars.

Both the surfaces of the tooth were used, as the study exclusively dealt with the effects of reconditioning of the bracket base on the shear bond strength. If only one of the surfaces would have been used, the values of the shear bond strength of the reconditioned brackets would also depend on the reconditioned enamel surface, enamel loss during debonding and other factors related to the enamel rather than depending only on the properties of the reconditioned bracket base. So in order to limit the variables and to study the effects of the reconditioned bracket base specifically on the shear bond strength; both the surfaces were used.

After the bonding procedure, the samples were stored in NSS at 37°C for 24 hours. The brackets were then debonded using Universal Testing Machine (UTM) (AGS-10kNG, Shimadzu, Japan) with a crosshead speed of 1.5 mm/min to produce a shear force at the tooth bracket interface.

Statistical analysis was performed using one-way ANOVA test for intergroup comparison and Post hoc Tukey for intragroup comparisons using SPSS for Windows, Version 16.0. (SPSS Inc, Chicago, USA). The level of

Table 2: One-Way ANOVA of Shear Bond Strength of two different bracket reconditioning methods with Control

Shear Bond Strength	SS	df	MS	F	p
Between Groups (A,B,C)	31637.02	2	15818.51	11.225	*
Within Groups	102877.20	73	1409.27		
Total	134514.22	75	-		

*Statistically significant (p < 0.05)

A, Heating/ Flaming; B, Sandblasting; C, Control

significance was established as p < 0.05 for all the statistical tests.

RESULT

The mean shear bond strengths of Group A (Heating/ Flaming), Group B (Sandblasting) and Group C (Control) were found to be 63.71 N, 100.42 N and 111.52 N respectively (Table 1).

Table 2 illustrates that there was an extremely significant difference between the means of the shear bond strengths of the three test groups (F= 11.225; p<0.00).

Post Hoc tukey test showed that the difference in the means of Group A (Heating/Flaming) and Group B (Sandblasting) were highly significant (p< .05). Also, the difference in the means of Group A (Heating/Flaming) and Group C (Control) were highly significant (p< .05). There was no significant difference in the means of Group B (Sandblasting) and Group C (Control) (p = .573) (Table 3, Table 1).

Group A shows the loss of mesh continuity in some areas and most of the adhesive residue still remained in the apertures. The surface texture of the mesh was near normal. Group B showed more number of clearer apertures with an intact but highly roughened mesh surface. The amount of adhesive residue in between the mesh structure is comparatively lesser than in Group A. Group C showed a fresh bracket base with all clear apertures, intact mesh and smooth surface. (Figure 1-5)

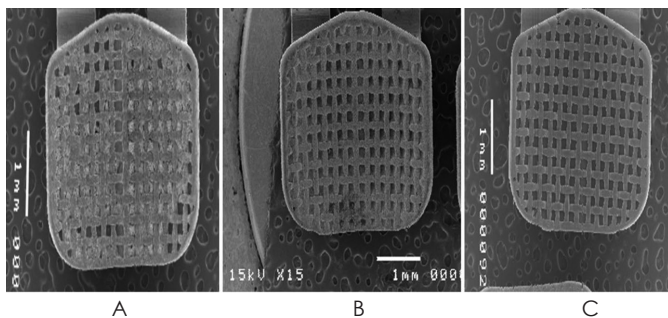


Figure 1: Scanning electron microscope images showing the bracket base at 15 X magnification. Heated/flamed bracket (A), Sand Blasted bracket (B) and a new unused bracket (C).

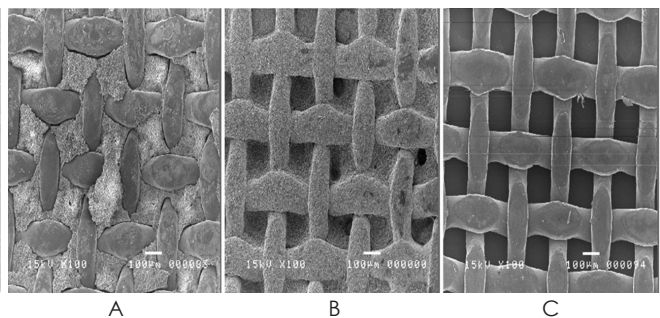


Figure 2: Scanning electron microscope images showing center of the bracket base at 100 X magnification. Heated/flamed bracket (A), Sand Blasted bracket (B) and a new unused bracket (C)

Table 3: Post Hoc Tukey Test describing the intra-group comparison of Shear Bond Strength of two different bracket reconditioning methods with Control (no reconditioning)

Shear Bond Strength Comparisons	Mean Difference(N)	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Heating Vs Sandblasting	-36.70*	10.03	-60.70	-12.70
Heating Vs Control	-47.79*	10.99	-74.09	-21.50
Sandblasting Vs Control	-11.09	10.99	-37.38	15.20

*Statistically significant ($p < 0.05$)

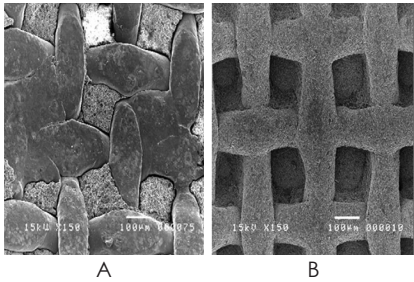


Figure 3: Scanning electron microscope images from the mesio-occlusal region of Heated/Flamed bracket base (A), and Sand Blasted base (B) at resolution 150 X.

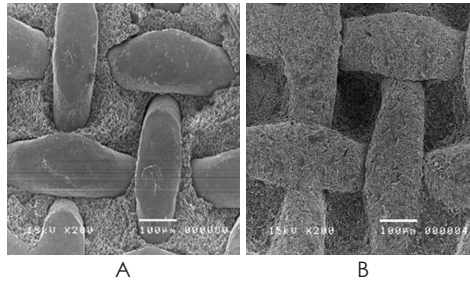


Figure 4: Electron microscope images from the disto-gingival area of Heated/Flamed bracket base (A), and Sand Blasted base (B) at resolution 200 X.

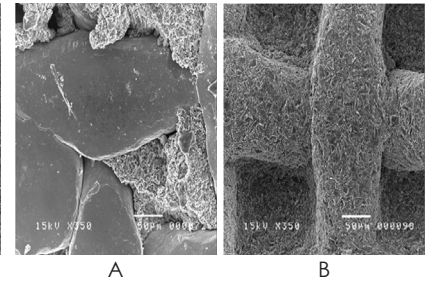


Figure 5: Scanning electron microscope images from the mesio-occlusal area of Heated/Flamed bracket base (A), and Sand Blasted base (B) at resolution 350 X.

DISCUSSION

Orthodontic treatment costs may vary across different countries or within the same locality depending on the socio-economic status of the population. Accidental dislodgement of the bracket in a posh dental may be conveniently replaced by a new bracket, but in a challenging dental setup it may not be convenient to use a new bracket for cases of dislodgement. Improvisation in the form of bracket recycling may be a brilliant option even today.

The aim of the bracket recycling/reconditioning is to separate the stains and adhesive remnants, resulting in brackets that reached standards comparable to those shown by unused brackets and were able to withstand the same draw-off strengths.^{18, 19}

Group C (Control) showed maximum shear bond strength (111.52 ± 49.90 N) which could be attributed to the fact that the bracket base had not been subjected to either modes of recycling which may have affected the bracket base physically or chemically (Table 1, Figure 1 & 2).

Group A (Heating/Flaming) showed reduced shear bond strength (63.71 ± 22.43 N) compared to the other two groups. This reduced shear bond strength could be attributed to the loss of surface properties of the bracket base during the procedure of heating/flaming such as the loss of mesh continuity and altered aperture dimensions.

It was noticed that the samples after being recycled with heat still had considerable amount of adhesive residue within the apertures (Figure 3-5).

The results of this study were consistent with those of Buchman in which he stated that if the bracket base was heated to over 400OC for a long time, a chromium carbide precipitate was formed and as a result partial disintegration of the alloy occurred leading to generalized weakening of the bracket.⁹

Group B (Sand Blasting) showed significantly higher shear bond strength values as compared to Group A (Heating/Flaming) ($p < .05$) but comparable bond strength values with Group C (Control) ($p = .573$). These results could be attributed to the increased micro-roughness created by the blasts of Al_2O_3 particles on the bracket base resulting in increased surface energy and surface area, thus increasing the bond. There was no visible loss of mesh continuity and no alterations in the aperture dimensions. These results were consistent with the results of Alluazy.²⁰

It was also noticed that the aluminum oxide particles had removed adhesive residue to a greater extent compared to Group A (Heating/Flaming) (Figure 3- 5). The results of this study were consistent with the findings of Wright and Powers, Regan *et al* who stated that the recycled brackets showed reduced shear bond strength values compared to new unused brackets.^{21, 22}

CONCLUSION

From the results of this study; it is concluded that:

1. Sand blasting as a method of recycling orthodontic bracket base provides higher shear bond strength compared to orthodontic brackets reconditioned by heating/ flaming.
2. The surface texture of the wire mesh of the bracket base is considerably rougher in cases of sandblasted brackets than in brackets that have been heated/ flamed leading to increased shear bond strengths.
3. There is more loss of mesh wire continuity in heated/ flamed brackets than those compared to the ones subjected to sand blasting.
4. The bracket base aperture dimensions is altered/reduced during heating/flaming but remains unchanged in case of sand blasting.
5. Sand blasting is more efficient in removing the adhesive residue from the orthodontic bracket base compared to heating/flaming
6. Sandblasting may be considered as a good alternative to recycle orthodontic brackets in a challenging dental practice with high cost of inventory and low socio economic conditions of the population.



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