Comparative Study of Shear Bond Strength of Recycled Brackets using different Recycling Techniques – An in vitro study

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ABSTRACT

Objective: To compare and evaluate the shear bond strength of recycled orthodontic brackets using different methods.

Materials & Method: A total of 50 extracted premolars and 50 metal brackets with a slot configuration of 0.022”x0.028” were used. All samples were divided into 5 groups with 10 samples each. Each group was further divided into 2 groups which were control group and experimental group. Experimental group was further subdivided into four recycle sub-groups. Tooth surface were prepared for bonding then brackets were bonded. The specimens were tested on Universal Testing Machine for shear bond strength. The force producing bond failure was recorded in Newtons (N) and converted into megapascals (Mpa).

Result: Shear bond strength of control group was maximum among all recycled groups. Shear bond strength of recycled brackets bonded with silane coupling agent and recycled with flaming, electropolishing, sandblasting and ultrasonic cleaning was equivalent to the control group. Brackets recycled with flaming and sandblasting had less shear bond strength as compared to control group. Brackets recycled with flaming and electropolishing were having the least shear bond strength.

Conclusion: Brackets recycled with flaming, ultra sonic scaling, electropolishing and treated with silane coupling agent was recorded with highest shear bond strength. Sandblasting of metal brackets to remove composite residue, had insignificant effect on the shear bond strength. Hence sandblasting should be considered as viable, time saving and convenient method of recycling.

Keywords: electropolishing, recycled brackets, sand blasting, shear bond strength, ultrasonic scaling

INTRODUCTION

The debonding of brackets is common in orthodontic practice. It may be due to bond failure or as a need for bracket repositioning. Typically practitioners shall discard dislodged brackets and replace it with a new bracket.[1] Using a new bracket is more time-efficient than reattaching the debonded bracket, however accidental debonding of a bracket require recycling procedure.

The bracket/resin interface is the usual site of failure with stainless steel brackets. Clinically, debonding of the anterior brackets is at the bracket/resin interface, whereas in posterior teeth it is more likely to present as enamel/resin break. Many factors predisposing to bond failure have been described. Occlusal stress during masticatory function is a major cause of debonding. In patients with excessive overbite, mandibular anterior brackets are especially susceptible to increased occlusal force and subsequent bond failure. Occlusal forces also play a role in mandibular canine bond failure in the form of “tripping” during canine retraction. Failure, especially with posterior teeth has been linked to poor access and moisture contamination, leading to inadequate enamel preparation.[2]

Various processes to recycle used metallic direct-bond brackets have been described. The procedures employed remove any residual bonding resin from mesh base of a bracket, and in some instances the process cause tarnish of the bracket surface, thus a polishing step is included as a part of recycling process.

The recycling procedures essentially fall into one of the two categories. In first process; the bracket is exposed to temperatures range of 427-454°C (800-850°F) to remove the residual bonding resin by controlled burning. The bracket is then subjected to electropolishing (Buchman, 1980; Vlock, 1981; Wheele and Ackerman, 1983). The second procedure uses unspecified chemicals to dissolve the resin remnants.

The main goal of recycling process is to remove the adhesive from the bracket completely without damaging or weakening the delicate bracket base meshwork or distorting the dimensions of the bracket slot. Reusing a debonded bracket traditionally requires burning off the residual adhesive with a flame then cleaning the bracket and restoring its shine with a micro etcher. A simple, quick, and inexpensive way to clean a bracket after the adhesive has been burnt off is to submerge the bracket for 5-15 seconds in a solution of 32% hydrochloric acid and 55% nitric acid mixed in 1:4 ratio. Commercial recycling processes use heat (about $450^{\circ}C$) to burn off the resin, followed by electropolishing to remove the oxide buildup at the bracket base. Some recycling companies advocate bicarbonate bath to neutralize remaining residual electrolytes from the base of the bracket after electropolishing.[3] The advantages of recycling a bracket includes smoother, more corrosion resistant bracket after electropolishing. The disadvantages of recycling may include a reduction in bracket quality, loss of identification marks, lack of sterility and increased risk of cross-infection.[4]

Many investigators have compared initial bond strengths with rebond bond strength and reached differing conclusions. Regan *et al* reported that initial bond strengths were equivalent to those of one rebond sample but were higher than those for the remaining three rebond samples.[5]

MATERIALS AND METHOD

A total of 50 extracted maxillary and mandibular premolars were used in this study. The criteria for tooth selection were as follow:

1. The crown was grossly perfect with no defect or any evident surface deformities.
2. No history of chemical insult with agents like hydrogen peroxide or formalin.
3. No history of trauma or any structural alteration caused by mechanical procedures.

A total of 50 metal brackets (premolar) with a slot configuration of 0.022”x0.028” were used. All samples were divided into 5 groups with ten samples each (Figure 1). Each group was further divided into 2 groups which were control group and experimental group. Experimental group was subdivided into four following sub-groups:

Sub-group I: Comprised of 10 brackets (Ormco) and recycled by flaming the base of the bracket and dipping the bracket into electropolisher.

Sub-group II: Comprised of 10 brackets (Ormco) and recycled by flaming of base and sandblasting the base of the bracket.

Sub-group III: Comprised of 10 brackets (Ormco) and recycled by flaming the base, cleaning the base with ultrasonic cleaner then dipped the bracket into electropolisher and using silane coupling agent in place of primer.

Sub-group IV: Comprised of 10 brackets (Ormco) and recycled by flaming and removing the remaining composite by ultrasonic cleaning.

Sample preparation: The sample constituted 50 extracted maxillary and mandibular premolars. The teeth were rinsed in tap water, scraped with a lecron spatula to remove periodontal tissue remnants and stored in 0.1% wt/vol thymol solution at room temperature in a closed plastic box. The teeth were embedded in sandstone poured ice-cube trays leaving only the crowns exposed, so that the labial force would be parallel to the applied force during shear bond strength. The teeth were then randomly divided into 5 groups.

Tooth surface preparation: Prior to bonding an orthodontic attachment to tooth surface, it is important to remove the enamel pellicle and create irregularities in the enamel surface. After surface preparation, the enamel surface was treated with acid etchant, the teeth were then rinsed and dried with air-spray.

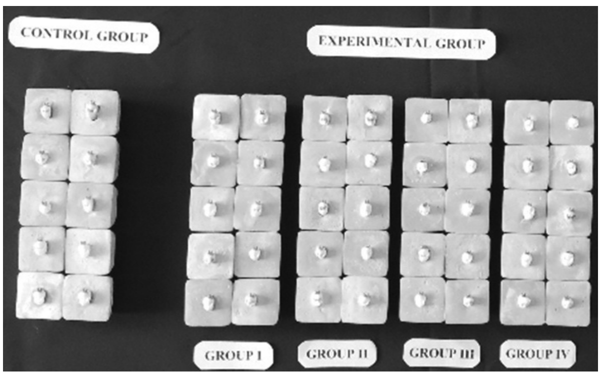

Figure 1: Sample groups

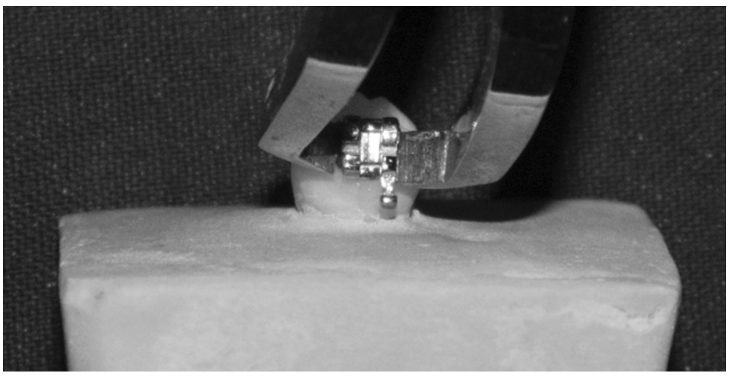

Figure 2: Diagram showing debonding of brackets

Table I: Shear bond strength of control group and experimental groups in mega-pascal (Surface area- 6mm²)

SN	Control Group	Experimental Group			
		Sub-group I	Sub-group II	Sub-group III	Sub-group IV
1	11.23	4.17	6.31	9.41	6.34
2	8.89	5.26	9.33	9.09	3.86
3	9.75	6.31	6.98	8.20	6.05
4	10.41	4.82	8.01	10.50	5.71
5	10.90	3.33	6.05	9.26	5.30
6	8.31	3.63	7.46	8.06	4.18
7	8.01	7.19	7.23	9.85	7.02
8	8.31	7.19	6.74	10.82	7.02
9	6.68	7.44	8.81	7.03	5.48
10	9.88	4.02	6.79	7.39	6.26

Bonding procedure: The primer (Transbond XT Primer, 3M Unitek) was applied on the enamel, a small layer of adhesive (Transbond XT, 3M Unitek) was applied to the bracket and was positioned on the pretreated crowns and then cured.

Shear bond strength testing: Brackets of all experimental samples were debonded after half an hour of initial bonding (Figure 2). This particular timing was chosen so as to approximate with the engagement of the initial archwires in a clinical scenario. The specimens were tested on Universal Testing Machine after 24 hours using a jig mounted positioned on the compression plates of machine. An occlusogingival load was applied to the bracket, producing a shear force at the bracket-tooth interface. A blade was placed at the bracket base-enamel interface at a crosshead speed of 0.5 mm/min until rupture of the bracket-tooth union. In this way the brackets were tested for bond failure. The force producing failure was recorded in Newtons (N) and converted into megapascals (Mpa) by dividing the measured force values by the mean surface area of the brackets.

Recycling of bracket bases: The entire samples of brackets were then recycled by flaming the bracket bases to burn off the residual composite and then electropolished, sandblasted, ultrasonic cleaning then silane coupling agent was used to the respective groups.

In Control Group, the stainless steel brackets were bonded on randomly selected teeth and the shear bond strength required for debonding each bracket was recorded by Universal Testing Machine. In Experimental Group, the debonded brackets were recycled using various techniques which were further divided into Subgroups I, II, III, IV and rebonded on premolar teeth and shear bond strength was measured by Universal Testing Machine.

RESULT

The shear bond strength of recycled brackets bonded with silane coupling agent and recycled with flaming, electropolishing, sandblasting and ultrasonic cleaning were equivalent to the control group. Brackets recycled with flaming and sandblasting had less shear bond strength as compared to Control group. Brackets recycled with flaming and electropolishing were having the least shear bond strengths.

Table 1 shows shear bond strength of control group and experimental group comprising of four sub-groups of ten brackets in each group with surface area of 11.2 mm² in mega pascals.

Table 2 shows mean shear bond strength of control group and experimental group. The mean shear bond strength of control group was found to be 9.24±1.24 Mpa.

Table 2 : Mean Shear bond strength of Control group and Experimental groups

Statistics	Control group	Experimental Group			
		Sub-group I	Sub-group II	Sub-group III	Sub-group IV
Number	10	10	10	10	10
Mean	9.24	5.31	7.37	8.96	5.56
Standard deviation	1.24	1.47	1.01	1.20	0.92

Table 3: Analysis of variance (ANOVA) of shear bond strength in Control group and Experimental Group

Source of Variation	Sum of Square	Degree of freedom	Mean sum of square	Variance Ratio “F”	*p*-value	F crit
Between Groups	135.187	4.000	33.797	20.779	9.31	2.579
Within Groups	73.190	45.000	1.626	-		
Total	208.377	49.000	-	-		

Since F value is significant; shear bond strength differ significantly in different groups. Shear bond strength was found maximum in control group.

The shear bond strength for brackets recycled with flaming, electropolishing, sandblasting, ultrasonic cleaning and bonded with silane coupling agent was significantly equivalent to control group when debonded after 30 minutes and shear bond strength measured after 24 hours.

DISCUSSION

Bunocore (1955) introduced etching technique and its application in direct bonding of brackets to the tooth surface, which largely simplified the time consuming procedure of fixed orthodontic treatment. The ease of bonding improved patient acceptance and assured its widescale application by orthodontists.[1]

The bracket consists of body and the base. The most commonly used method for retention is the mesh pad incorporated at the bracket base which is generally made by the lamination of fine mesh to foil. The foil mesh type of base has been widely used and provides adequate tensile & shear bond strengths.

Various chemical and mechanical retentive designs have been suggested to enhance the retention of the adhesive to the metal base of orthodontic brackets. Chemical retention is provided by chemically etched bases, metal plasma-coating on bracket bases.

This study was designed for comparison of shear bond strength of metallic orthodontic brackets recycled with different recycling methods. Studies have suggested shear bond strength values ranging from a low of 5.9Mpa to a high of 7.8 Mpa for clinical usage.[6]

Recycling consist of the removal of remnant bonding agent on the bracket bases, without causing damage to the retention mesh and preserving retentive characterstics.[6] Several techniques are available for recycling brackets. Mechanical methods: Sandblasting Aluminium Oxide blasting- 50 μm, 90μm particles etc), Ultra sonic scaling, Thermal Methods, Chemical methods, Combination of mechanical and thermal methods.

According to Quick *et al*; sandblasting for a period of 15 seconds using 50μm aluminium oxide granules at a pressure of 4.5 bar was adequate to remove the residual composite without compromising the bond strength.[7]

These methods have been subjected to several investigations to prove their efficacy. Marked reduction in the bracket bond strength was reported after grinding the adhesive with a green stone to the surface of the mesh base.[8] In addition, a study by Regan *et al*[5] revealed that Buchman method[9] also cause decrease in bond strength.

On the other hand, sandblasting with aluminum oxide particles (90 micron) for 15-30 seconds at a distance of 10 mm from the bracket bases is efficient and technically simple, as reported by Tavares *et al*.[6] It also enhance bracket bonding to tooth structure by producing micromechanical retention on base surface due to the increase in the area of composite interlocking, which is essentially mechanical due to the microasperity of the bracket mesh. These reasons positively guided us to choose sandblasting with aluminium oxide to be the method of choice for recycling in the present study.

CONCLUSION

Brackets recycled with flaming, ultrasonic scaling, electropolishing and treated with silane coupling agent was recorded with highest shear bond strength. Sandblasting of metal brackets to remove composite residue had insignificant effect on the shear bond strength. Hence sandblasting should be considered as viable, time saving and convenient method of recycling.

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