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COMPARISON OF DIFFERENT BRACKET RECYCLING METHODS ON SHEAR BOND STRENGTH

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ABSTRACT

Background: Choosing what to do with debonded or incorrectly positioned brackets is a regular dilemma for orthodontists. Recycling the brackets is a cost-effective solution to this problem. Although numerous recycling techniques have been put forth, more research is necessary to determine the ideal bond strength of these recovered brackets.

Objectives: To evaluate and compare the effect of six recycling methods: (i) Direct flaming (ii) Greenstone Bur (iii) Acid bath solution (iv)Sandblasting(v) Butchman Method (vi) Ultrasonic on shear bond strength (SBS) of stainless steel brackets.

Material and Methods: One hundred eighty human premolars were bonded with premolar stainless steel brackets as per manufacturer's instructions. The teeth were divided into 6 groups (n=30): After initial bonding, the brackets in the six experimental groups were debonded and recycled by following methods:(i) Direct flaming (ii) Greenstone Bur (iii) Acid bath solution (iv)Sandblasting(v) Butchman Method (vi) Ultrasonic . Further the recycled brackets were bonded. The specimens were then subjected to testing in a Universal machine. The evaluation of the variation of the shear bond strength (SBS) among test groups was done using one-way ANOVA test and followed by post hoc multiple comparison test.

Results: the mean shear bond strength for each group is presented. After sandblasting (7.26 ± 0.20 MPa), the Butchman recycling method (8.45 ± 0.29 MPa) offered the highest bond strength. The methods that provided the lowest shear bond strength were acid etch (4.22 ± 0.21 MPa) and ultrasonic (4.59 ± 0.18 MPa). Statistically significant variations existed in the shear bond strength (SBS) in all groups analyzed.

Conclusions: T Shear bond strength of recycled brackets by Butchman's Method is significantly higher than the other five methods. Brackets recycled with flame method and brackets sandblasted with 50µm aluminium oxide particle air-abrasion showed significantly shear bond strength which is clinically acceptable to be used as resuable brackets. Brackets recycled with, acid bath, ultrasonic and greenstone bur showd clincically insigificant result to be used after recycling.

INTRODUCTION

Debonding of the brackets during ordinary orthodontic treatment is the largest obstacle an orthodontist has in his or her daily clinical practice. This problem typically affects both the patient and the clinician1. Bond failure of orthodontic brackets occurs during orthodontic treatment and may be caused by neglecting to follow the manufacturer's instructions, which include properly cleaning the tooth surface before applying etching, then properly sanitising the tooth surface to prevent blood and saliva from getting on it, applying the bonding agent, attaching the bracket to the tooth surface, and curing. A variety of techniques are used to safely remove resin after debonding and enable rebonding. As a result, numerous chairside tools and technical processes were invented. These include the application of air abrasion/sandblasting, soflex disc, diamond burs, tungsten carbide burs (TCA), and flaming procedures (Buchman Method), which entail applying a direct flame to the bracket base to burn off the composite material, followed by electropolishing. 1 The bond strength may be impacted by carelessness during the process or by recontamination of the tooth surface by saliva, blood, etc. after etching. Rebonding is a clinical process that involves cleaning the bracket base and removing any composite remnants after the debonded or dislodged orthodontic brackets have been treated to a variety of commercial conditioning treatments. The bonding surface (mesh) undergoes both macro and microscopic structural changes as a result of this process, and a new surface area is produced for the rebonding of the bracket to the tooth surface 2. For treatment to be successful, the rebonded brackets' bond strength is crucial.

Since a single bracket may be recycled and reused up to five times on the same patient, the greatest benefit of this sort of chairside recycling and rebonding procedure is cost savings and reduced risks of distortion, which might be as high as 90% 3. Additional benefits include sterility due to the temperatures used in these recycling processes and a smoother, more corrosion-resistant bracket following electro polishing. Loss of identification markers is one drawback, but the newest brackets have laser numbered markings.

Various commercial and chairside recycling methods are available. The first commercial process developed by Esmadent uses heat application for recycling whereas the other method, proposed by Orthocycle, utilizes chemical solvents for this purpose. (4) The drawbacks of these methods include mesh shape distortion, corrosion and loss of metal in certain areas, shear bond strength decrease of 6%–20%. (5) Chairside techniques include mechanical (grinding with burs or

greenstone, sandblasting, bond removing pliers) and thermal methods (the Buchman method, laser, direct flaming). (4)

Recycling of bracket base by grinding is done by using a green stone bur in a straight slow speed handpiece at a speed of 25,000 RPM for 25 sec. Precautious removal is done to prevent damage to the base mesh work. (4, 6)

Sandblasting method using powder of 50µm aluminum oxide particles sandblasted from a distance of 10mm between the micro etcher and bracket base under 90 PSI air pressure until no residual adhesive is visible on the base and the metal base have a frosty appearance. Next, the bracket is dried using compressed air. (6, 8, 10, 11)

The base of the bracket is heated using non luminous region of flame of micro torch until the bracket base appears cherry red indicating burned residual adhesive on the base. Next, the bracket is quenched in cold water and air dried in the Direct Flaming method. (4, 5, 6, 7, 8)

Buchman Method uses bunsen flame for 5-10 seconds until the bonding agent start to burn and then quenched in water at room temperature. Then a sand blasting with Aluminum oxide particles is done for 5 sec at pressure of 90 pounds per square inch and distance of the sand blaster kept at 10mm. Lastly, the bracket will be placed in electropolisher. (6)

Acid bath recycling Method works by burning off the adhesive with the help of micro torch, the next step is to immerse the bracket in a solution of 32% hydrochloric acid and 55% nitric acid for 5 to 15 sec, combined in a ratio of 1:4. This procedure quickly eradicates any stain, has a antiseptic outcome and also dissolves any resin residue. (6)

Ultrasonic cleaning of brackets for 10 minutes till the adhesive residue is wiped out. (4) (8)

Clinically optimal shear bond strength (SBS) of an orthodontic bracket is shown to range from 6.8–7.9 MPa. (4) According to Reynolds 5.9 MPa to 7.8 MPa was proposed to be the clinically significant range for bond strength. (8)

Shear bond strength concluded from a study were reported to be 13.8 ± 0.68 MPa for grinding method; 19.79 ± 2.02 MPa for sandblasting method; 18.85 ± 1.32 MPa for the direct flaming

method; 18.60 ±2.02 for Buchman method; 19.13 ± 2.07 MPa for the acid bath method (6) and 11.04 ± 4.11 MPa for the ultrasonic cleaning method of bracket recycling (9) .
Previous studies have reported that recycling with faming results in shear bond strength below the recommended range of clinical need (4, 5, 7, 8) , while recycling with sandblasting gives clinically acceptable shear bond strength (4, 6-10) SBS of brackets recycled by flaming with sandblasting was reported much less in a study by Gupta et al (2.05 MPa) and large value (26.94 MPa) was reported in a study by Bansal et al [8] However, limited studies are available in literature about the effects of recycling orthodontic brackets with ultrasonic cleaning on shear bond strength.
Flaming with ultrasonic cleaning group (5.97 ± 0.66 MPa) and the least SBS was obtained with the Flaming only group (4.30 ± 0.55 Mpa) [12] Quick et al. and Kumar et al reported shear bond strength of brackets recycled with ultrasonic cleaning less than the recommended bond strength (less than 6 MPa), while Chetan et al. reported this within the recommended range [8]. .
Of all the proposed methods for recycling it is yet not clear which method provide the best results of adhesive removal and clinically optimal bond strength. (9) There is also lack of local data on this topic. Thus, the rationale of this study is to compare the shear bond strength of various chairside recycling techniques. This will have significant clinical value as it will decrease the time of the procedure where new replacements will be costly without compromising on the bond strength of recycled brackets.

Material and Methods

-Objectives

1. To evaluate the effect of following total six in-office and commercial recycling methods on shear bond strength of orthodontic brackets

2. To compare the shear bond strengths of orthodontic brackets recycled by three different methods.

-Methodology

This in vitro study was carried out at the Department of Orthodontics, DIKIOHS, DUHS and Metallurgic department of NED University.
One hundred eighty healthy human premolars extracted for orthodontic reasons were collected from Department of Oral and Maxillofacial Surgery.
The following criteria were considered:

Inclusion criteria:
• Extracted premolar teeth
• Premolar brackets
• Same base design of brackets
• Single type of primer and adhesive

Exclusion criteria:
• Previously recycled brackets
• Distorted brackets
• Crown with any evident surface deformity like cracks, fracture lines or hypoplasia
• Teeth pre-treated with a chemical agent.

Research Design

This is an experimental in vitro study

Method of study:

One hundred eighty premolar teeth which were extracted for orthodontic purpose were selected for this study. The teeth did not undergo pre treatment with a chemical agent such as alcohol, formalin or hydrogen peroxide. These teeth were thoroughly cleaned of any soft tissue and blood and stored immediately in saline to prevent dehydration till the study was conducted. Pre-adjusted edgewise premolar brackets of 0.022” (3M Unitek, Gemini M.B.T, Monorovia ,USA) were used in the study. The teeth were divided into six groups: Group I: Brackets recycled with green stone bur. Group II: Brackets recycled by flame (Torch method) . Group III: Brackets recycled by sandblasting aluminium oxide 50 microns for 20-30 secs. Group IV: Bracket recycled with Acid bath 32% hydrochloric acid and 55% nitric acid in the ratio of 1:4 plus high frequency vibrations. Group V: Bracket recycled with ultrasonic cleaning for 10 minutes Group VI: Bracket recycling with Buchman method (direct flaming followed by sandblasting and electropolishing)
Teeth in each group were mounted vertically on dental plaster blocks. The dental plaster bases were covered up to the usual level of alveolar bone around each premolar tooth. Teeth were aligned with the facial surface of the tooth perpendicular

with the bottom of the mold; i.e., each tooth was oriented so its labial surface would be parallel to the force during the shear strength test. The teeth were kept outside the saline water only for a very short time to prevent any dehydration. The teeth were cleaned and then polished with non-fluoridated pumice and bristle brush for 15 seconds and air stream for 10 seconds.

ºBonding protocol

The bonding approach followed the manufacturer's instructions. All one hundred and eighty premolar teeth were bonded [Transbond XT(3M Unitek)]. The procedure included acid etching with a 37% phosphoric acid gel (EAZETECH, Anabond, Tamilnadu) for 30 seconds followed by thorough washing and air drying for 20 seconds. The sealant was placed on the tooth, and the brackets [pre-adjusted edgewise premolar brackets of 0.022" (3M, M.B.T prescription)] were bonded with the chemical cure adhesive (Unicorn MedidentPvt. Ltd,).

ºDebonding procedure

Debonding was done with debonding pliers for the six experimental groups [Group I-Group VI].

ºRebonding

The adhesive remaining on the teeth after debonding was removed with a tungsten carbide bur. Rebonding of the recycled brackets was done using standard bonding procedure as described earlier.

ºFinal debonding

A customized jig was suspended from the crosshead of a UNIVERSAL TESTING MACHINE (TUE-C-400, Fine Spavy Associates & Engineers Pvt. Ltd., Miraj). A gingivo-occlusal load was applied to the bracket, producing shear force at the bracket-tooth interface for all the four groups. A computer, electronically connected with the test machine, recorded the results of each test. Shear bond strengths were measured at a crosshead speed of 0.5 mm/ min. The force required to break the bracket-enamel bond was recorded in Kilo Newtons (kN) and converted to megapascals (MPa) using the surface area of the bracket base. The following equation was used for the conversion. Stress (Mpa) = Force(kN) × 103 Area (mm square)

Statistical Analysis

Mean shear bond strength of every group is reported. The normality was checked using Shapiro-Wilk test along with Levene's test of homogeneity. The data followed normal distribution, thus One-Way ANOVA was applied to compare means of all bracket recycling methods. Post Hoc Tukey was applied for multiple comparisons. A significance level of 0.05 was used for all statistical analyses.

Results

In Table 1 and Figure 1, the mean shear bond strength for each group is presented. After sandblasting (7.26 ± 0.20 MPa), the Butchman recycling method (8.45 ± 0.29 MPa) offered the highest bond strength. The methods that provided the lowest shear bond strength were acid etch (4.22 ± 0.21 MPa) and ultrasonic (4.59 ± 0.18 MPa).

According to the Shapiro-Wilk test, the data was found to be noramlly distributed (Table 2). With a p-value of 0.003, Leven's test revealed that the data was homogeneous. Once the presumptions were satisfied, the means of the shear bond strength in each of the six groups were compared using a one-way ANOVA. According to the test, there was a statistically significant difference in the groups' shear bond strengths (Table 3). To compare groups, Tukey's post hoc test was used. Every post hoc p-value was less than 0.001, indicating a statistically significant difference in each group's shear bond strength (Table 4). Our findings rejected the null hypothesis, indicating that orthodontic brackets recycled in various ways have varying shear bond strengths.

Table 1: Mean ± S.D of shear bond strength of all recycling methods

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
flame	30	6.2077	.16976	.03099	6.1443	6.2711	5.89	6.50
greenstone	30	5.0110	.16236	.02964	4.9504	5.0716	4.63	5.28
acidetch	30	4.2290	.21426	.03912	4.1490	4.3090	3.60	4.54
sandblast	30	7.2683	.20267	.03700	7.1927	7.3440	6.90	7.81
butchman	30	8.4550	.29701	.05423	8.3441	8.5659	7.89	8.91
ultrasound	30	4.5900	.18011	.03288	4.5227	4.6573	4.12	4.90
Total	180	5.9602	1.53321	.11428	5.7347	6.1857	3.60	8.91

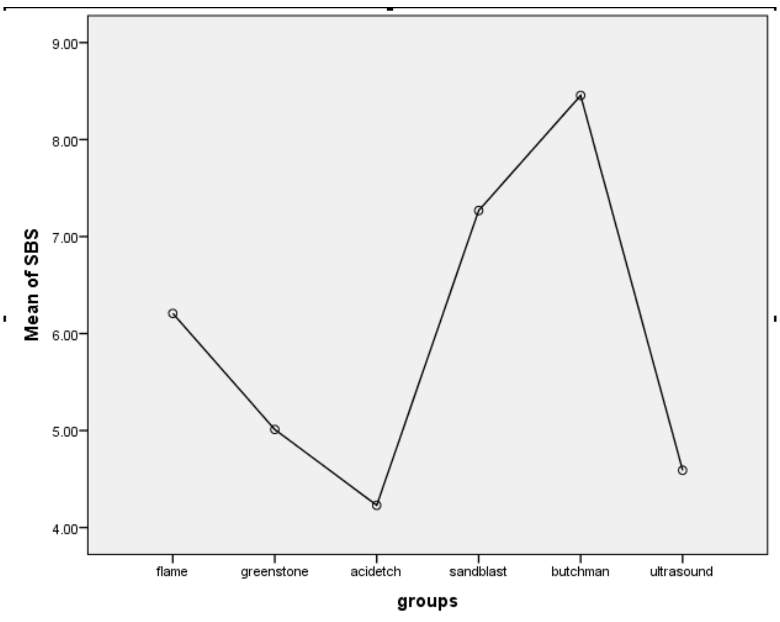

Figure 1: Means Plot of recycling methods

Table 2: Test of Normality

	groups	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
SBS	flame	.129	30	.200*	.951	30	.175
	greenstone	.087	30	.200*	.975	30	.691
	acidetch	.146	30	.101	.936	30	.070
	sandblast	.095	30	.200*	.967	30	.466
	butchman	.179	30	.015	.948	30	.150
	ultrasound	.106	30	.200*	.965	30	.418

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 3: One-Way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	413.159	5	82.632	1886.460	.000
Within Groups	7.622	174	.044		
Total	420.780	179			

Table 4: Tukey's Multiple Comparison Post Hoc test

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
flame	greenstone	1.19667*	.05404	.000	1.0409	1.3524
	acidetch	1.97867*	.05404	.000	1.8229	2.1344
	sandblast	-1.06067*	.05404	.000	-1.2164	-.9049
	butchman	-2.24733*	.05404	.000	-2.4031	-2.0916
	ultrasound	1.61767*	.05404	.000	1.4619	1.7734
greenstone	flame	-1.19667*	.05404	.000	-1.3524	-1.0409
	acidetch	.78200*	.05404	.000	.6263	.9377
	sandblast	-2.25733*	.05404	.000	-2.4131	-2.1016
	butchman	-3.44400*	.05404	.000	-3.5997	-3.2883
	ultrasound	.42100*	.05404	.000	.2653	.5767
acidetch	flame	-1.97867*	.05404	.000	-2.1344	-1.8229
	greenstone	-.78200*	.05404	.000	-.9377	-.6263
	sandblast	-3.03933*	.05404	.000	-3.1951	-2.8836
	butchman	-4.22600*	.05404	.000	-4.3817	-4.0703
	ultrasound	-.36100*	.05404	.000	-.5167	-.2053
sandblast	flame	1.06067*	.05404	.000	.9049	1.2164
	greenstone	2.25733*	.05404	.000	2.1016	2.4131
	acidetch	3.03933*	.05404	.000	2.8836	3.1951
	butchman	-1.18667*	.05404	.000	-1.3424	-1.0309
	ultrasound	2.67833*	.05404	.000	2.5226	2.8341
butchman	flame	2.24733*	.05404	.000	2.0916	2.4031
	greenstone	3.44400*	.05404	.000	3.2883	3.5997
	acidetch	4.22600*	.05404	.000	4.0703	4.3817
	sandblast	1.18667*	.05404	.000	1.0309	1.3424
	ultrasound	3.86500*	.05404	.000	3.7093	4.0207

Discussion:

Bond failure during orthodontic treatment is relatively frequent and undesirable. As a result, the shear bond strength of recycled brackets has been a subject of great interest in orthodontic research (1). In our study lowest bond strength was obtained for Group III which was acid bath method. This is inconsistent with the observations made by Dawjee who found that sandblasted flamed brackets had no significant effect on shear bond strength of brackets (4). In our study the highest bond strength was for Group V which consisted of Butchman method of bracket recycling which includes sandblasting followed by electropolishing. This results are in consistent with a study by Samir.E.Bishara who explains that in general, the highest values for shear bond strength were obtained after the recycling (10).

The shear bond strengths of Group III and Group VI were quiete low to be used as recycled bracket because it shows statistically very low. Direct flaming and sandblasting methods showed a border line bond strength which is clinically acceptable for recycled brackets. The acid bath treatment just made the brackets more esthetically acceptable without adding to bond strength.

The optimal bond strength required for orthodontic clinical use is as yet unknown (5). Reynolds in 1975 suggested that for an adhesive system to have acceptable clinical performance, in vitro bond strength of 5.9-7.8MPa is required (6).

The nature of the forces directed onto orthodontic brackets in the mouth is likely to be a combination of shear, tensile and torsion. The bond strength of bracket -adhesive - enamel system in orthodontic bonding varies and depends on factors such as the type of adhesive, bracket base design, Storage media, enamel morphology, appliance force systems and the clinician's technique. The universal testing machine used in vitro studies is capable of producing only pure debonding forces (shear, tensile or torsion) not the combination of them and other conditions is not possible to simulate. In addition, the rate of loading for the universal testing machine is constant, whereas the rate of loading for in vivo debonding is not standardized or constant (8). These are a few among the many factors, which may contribute to the variability and difference of opinion among researchers regarding the clinically acceptable bond strength.

The shear bond strength of butchman group (Group V) is close to the available optimal bond strength value in literature. Moreover, recycling techniques used in Group III and Group VI show too low values and cannot be recommended as an effective recycling method. Hence in light of the results presented in our study it can be said that shear bond strength of recycled brackets by butchman method is same cpmapred to new brackets though some inconsistent results have been reported by some researchers (2,10,11). Brackets sandblasted with 50µm aluminium oxide particle airabrasion was efficient and technically simple, and might provide cost reduction for orthodontists and patients. Sandblasted brackets treated showed a border line shear strength to be used clinically (4,6,8)

The nature of the forces directed onto orthodontic brackets in the mouth is likely to be a combination of shear, tensile and torsion. However, in our study just shear forces were evaluated. The rate of loading for in vivo debonding is not constant as oral cavity is in a constant dynamic state whereas the rate of loading for the universal testing machine is constant. To date, however, the clinical bonding performance of the recycled brackets has not been investigated. A prospective,longitudinal in vivo clinical study is needed to determine whether recycled brackets can provide clinically acceptable bond strength compared with new brackets.

Conclusions

Shear bond strength of recycled brackets by Butchman's Method is significantly higher than the other five methods. Brackets recycled with flame method and brackets sandblasted with 50µm aluminium oxide particle air-abrasion showed significantly shear bond strength which is clinically acceptable to be used as resuable brackets. Brackets recycled with, acid bath, ultrasonic and greenstone bur showd clincically insigificant result to be used after recycling.

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