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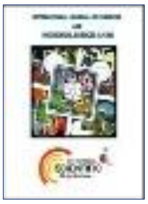

Comparison of Shear Bond Strength of the Orthodontic Brackets After Different Methods of Recycling

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Abstract

Bonding failure is recognized as the main concern in the daily practice of orthodontics. The debonded bracket is usually redonded on the tooth surface. Different recycling techniques have been used such as sandblasting or thermal treatment to remove the remnant composite that has been attached to the base of the bracket and to enhance the effectiveness of bracket bonding to the tooth surface. Many studies evaluating the effect of recycling on bracket bond strength have shown that the recycling produces statistically significant reduction in the bond strength when compared to the newly bonded brackets. The recycling techniques also produce a slight change in the bracket slot, distortion of the bracket and a reduced resistance to corrosion. The aim of this study is to compare the shear bond strength of the orthodontic brackets after different methods of recycling with that of the initially bonded brackets. In this investigation, the shear bond strength of three different methods of recycling such as sandblasting, heat treatment and handpiece is compared with the Primary bonding strength. The mean shear bond strength for primary bonding interface (controlled samples) of the brackets was 54MPa. These values for rebounded brackets using three different techniques of sandblasting, heat treatment and handpiece were 48.6MPa, 46MPa and 21MPa respectively. The shear bond strength of one-time sandblasting, thermal treated, two-time sandblasting and Hand piece groups are less than the newly bonded brackets. Although this difference is a clinical fact, it was not recognized statistically significant. Among the five methods, the one-time sandblasting and the thermal treated groups showed stronger bonding strength than the other two groups.

Keywords: Fixed orthodontic appliances, Orthodontic braces, Recycling, Shear strength

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1. Introduction

Orthodontic treatment usually requires the use of fixed appliances. These appliances consist of attachments, are bonded directly to the tooth surface, and should remain until the end phase of active treatment. However, some of them fail in service. Bracket debonding, whether performed accidental or deliberately by the orthodontist, is a fairly frequent event as the orthodontic treatment proceed. Regardless the cause of debonding, the orthodontist must decide whether to rebond the same bracket or bond a new bracket. In orthodontics, as well as in other fields of dentistry, there is a tendency to streamline the technical procedures to reduce chair time and treatment costs. The reduction in cost by using recycled brackets represents a significant financial advantage when bonding the orthodontic brackets. Brackets can be recycled both indirectly by sending them to external specialized reconditioning services or directly in the orthodontic clinic. [1, 2].

From a clinical point of view, the success of bonding is of major importance. Fortunately, this bond is fairly strong enough to bear occlusal stress and shear forces. However, bonding failure frequently happens especially in youngsters in practice of orthodontics. This makes the subsequent appointments longer and troublesome. In addition, some technical errors may weaken this attachment, i.e. moisture control, clinical technique and bonding material.

Most orthodontic brackets are made of austenitic stainless steel, which contribute in chrome-carbide compounds formation that precipitate at temperatures between 6000C and 8000C. This process leads to disintegration of the metal alloy and weakens its structure. In addition, corrosion strength decreases due to chromium loss via carbide precipitation. Preparing same bracket for re-bonding is performed in different ways. Recycling done to remove the remnant composite from the base of bracket and also to maintain its retentive configuration is a method of rebonding. However, this preparation process is technically performed by four means,

1.1. Heat treatment

In this type of treatment composite is burned from bracket base and then the formed oxide layer is removed with an electropolishing device. This, however, can alter the microstructure of bracket mesh. Unfortunately, steel bracket at 6000C to 8000C heat converts to chrome-cobalt compound. This phenomenon results in weakening the microstructure of bracket causing low corrosion strength, because of disintegration of metal compound.

1.2. Chemical removal

Chemical solvent can be applied for composite removal from the base of bracket. This is done along with electric vibrator under high frequency and completed with electrochemical polishing procedure.

1.3. Sandblasting method

The bracket base is cleaned under compressed air flow with silicone carbide stone particles or with aluminum oxide particles. Sandblasting provides better micro-roughness and subsequently better bonding and leading to better micromechanical retention. This method was also recommended for new brackets leading to improved bond strength.

1.4. Re-etching technique

There is an evidence that composite surface becomes more porous when exposed to etching gel. This creates a new micromechanical surface on bracket and more retention when bonded to tooth. The effects of recycling depend on the type of reconditioning process used, the type of alloy from which the bracket is constructed, and the procedure by which the bracket is prepared.i.e., whether the bracket is constructed using milling or casting, and whether the bracket has a mesh pad or a non-mesh undercut integral pad. This process increases the micro asperity of the bracket mesh and the area of composite bonding.

Among the different methods used in industrial recycling, the most commonly used method is application of heat to burn the bonding agent followed by electrolytic polishing to eliminate the remaining oxide layer, or they use chemical agents to dissolve the bond agent in combination with high frequency vibration and electrochemical polishing. 3-5 Various studies have observed a reduction in shear bond strength (SBS) of 6%–20% after industrial bracket recycling, 6 reaching 35% for finer mesh-type brackets. 4 However, one in vivo study 7 compared the clinical behavior of industrially recycled brackets and new brackets with a 12-month follow-up but found no significant differences in bond failure percentages. Other studies have reported some loss in metal parts of the bracket and a reduction in the diameter of the mesh wires among commercially recycled brackets, whether reconditioned using heat or chemicals [4, 6, 8]. Nevertheless, these changes did not seem to affect bond strength [1, 8].

The other option—recycling in the clinic—can use various techniques: mechanical (micro sandblasting), thermal (direct burning), or mixed. Nowadays, sandblasting is widely used, and numerous studies [9-14] have shown that sandblasting increases the bond strength and survival time of new brackets. Studies comparing the reconditioning methods used in the clinic has concluded that sandblasting is the most effective method for removing bond material, while no significant differences in bond strength were identified between brackets recycled by this means and new brackets [15-17].

Studies of brackets that have undergone successive recycling show contradictory results. Regan et al. [18] found no significant differences in SBS among metal brackets that had been recycled up to five times, while Buchwald 5 found that the percentage of brackets that could be reused decreased with each successive recycle. Martina et al. [19] found no significant dimensional changes in industrially reconditioned ceramic brackets recycled up to 10 times but did find slight reductions in SBS in comparison with new brackets. For Matasa, 11 the main advantage of recycling is the economic savings, which can reach 90% if a single bracket is recycled five times. As far as we are aware, no studies to date have compared brackets recycled by means of sandblasting, thermal or heat treatment, and with handpiece, nor has any research been carried out into the effects of various sequential recycles of a single bracket by means of these procedures.

The aim of this study was to evaluate in vitro the effects of reconditioning metal brackets by sandblasting after first and second rebondings/recycles, thermal or heat treatment and also by using handpiece.

2. Methods

The study used 25 extracted teeth including both anteriors and posteriors. They were first submerged in hydrogen peroxide (H_2O_2) solution to remove ant debris present around the tooth structure. Afterward the teeth were placed in the distilled water, until the moment of use to avid deterioration. The SBS test used all the 25 teeth.

2.1. Brackets

The study used 25 orthodontic metal brackets for SBS testing.

2.2. Bonding procedure

The vestibular surfaces of the teeth were cleaned using prophylactic cream, polished and then dried with compressed air. For etching of the buccal surface of the teeth, Transbond Plus Self Etching Primer (3M Unitek Dental Products) was used according to the manufacturer's instructions. The teeth were etched for 15 seconds, rinsed and dried to obtain a chalky white appearance. We used primer (Transbond XT) for bonding of brackets. Transbond XT composite (3M Unitek, Monrovia, CA, USA) was applied on standard pre-adjusted edgewise premolar bracket base with 0.022*0.018-inch slot size according to the manufacturer's instructions. Brackets were then bonded to the middle part of the buccal surface by applying equal force. After aligning the longitudinal axis of the bracket parallel to the longitudinal axis of the tooth, excess adhesive was removed by a scaler and light curing was performed using a light curing unit (Woodpecker) with 1200 mW/cm2 intensity. Each tooth was cured for 40 seconds from the mesial, distal, occlusal and gingival surfaces. All procedures were performed by the same operator. Specimens were submerged in distilled water at 370C for 24 hours.

2.3. Bracket Base cleaning procedures

Brackets were randomly divided into 5 groups according to cleaning method:

Group 1: Normal brackets (Control)
Group 2: Sandblasting using Al_2O_3
Group 3: Sandblasting two times using Al_2O_3
Group 4: Thermal or heat treatment
Group 5: cleaning using Hand-Piece

The bonding/ debonding procedures was repeated for all the brackets except the brackets in the Group 1. The same tooth was used for each successive bonding. The brackets were all bonded using the same procedure as described above.

2.4. SBS testing

Universal testing machine (INSTRON) was used for SBS testing. The teeth were placed in the machine such that the bracket base was parallel to the load application vector. Load was applied in occlusogingival direction at a crosshead speed of 1 mm/minute to the bracket-tooth interface. Load at debonding was recorded in Newtons (N) and converted to Megapascals (MPa) by dividing the load in Newtons by the bracket base surface area in square-millimeters (mm^2).

2.5. Statistical analysis

The SBS for the four cleaning procedures were compared after each debonding sequence. Comparisons were also performed to determine whether significant differences existed in SBS between the debonding procedures within each bracket base cleaning procedure. The one-way ANOVA analysis ($P < .05$) was applied to the data for bond strength after debonding.

3. Results

According to the result of this study, the mean SBS in the control group was 54MPa with SD of 2.79. In the sandblasted group, the mean SBS value for one-time sandblasting was 48.6MPa with the SD of 3.59 and the mean SBS value for two-time sandblasting was 43MPa with the SD of 2.32. For the thermal (heat) treatment group the SBS value was 46MPa with the SD of 1.55. For the hand piece treated group, the mean SBS value was 21MPa with the SD of 1.00. All these values are presented in the Table 1.

The SBS values indicated that the strongest bonding occurs between the bracket and fresh tooth at the first time. The brackets which were recycled using the hand-piece showed the weakest bonding when compared to all the other groups. However, the ANOVA analysis did not show any statistical difference amongst all five groups (p-value=0.169). The related statistical values are presented in Table 2.

4. 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 [20]. 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. Successful orthodontic treatment depends on the adequate bond strength of brackets to enamel. It is extremely difficult to obtain adequate bond strength with recycled metal brackets adding to the fear of debonding. Metal primers have claimed to promote adhesion to metallic surfaces, as also Cojet sand (3M ESPE) has claimed to be effective in increasing the bond strength due to the tribochemical reaction.

According to several authors aluminum oxide air-abrasion has been proved to be a good option for bracket recycling by offering a simple and easy technique, which can be performed in the dental office, thus reducing the cost and working time. It also creates a micro-roughened surface on the bracket base, which increases the area available for composite bonding.

Several techniques are used for recycling of orthodontic brackets to remove the remaining adhesives. These methods include air abrasion, wear by silicon carbide bur, microetching, lasers and industrial recycling procedures. Each method should provide acceptable bond strength, create less destructive side effects, be easy to use and less time consuming. The purpose of recycling is to remove the remaining adhesives completely from the bracket base without causing any damage or change the bracket slot dimensions. Although the required bond strength for clinical work has not been determined specifically and previous studies have reported different values, this parameter should be high enough for the bonded bracket to resist chewing forces. On the other hand, the bond strength should allow easy debonding of the bonded brackets without damaging the tooth enamel.

There are several methods of force application which can be used in bracket-debonding studies, including shear, flexural and tensile tests. In the clinical conditions, the orthodontic brackets may be subjected to different combinations of arch-wire forces, occlusal forces from the opposing teeth, and the forces that were used for the intentional debonding of the brackets. A shear type of force application can be used to replicate the effects of occlusal forces, which have been suggested to be the most important cause in bracket bond failure on the posterior teeth [21].

New brackets provide the strongest bonding with fresh teeth. Orderly, the one-time sandblasted and thermal treated brackets make reasonable bonding strength to the tooth. Nonetheless, these differences were not statistically significant (p-value= 0.125). These bonding strength differences were in accordance with the results of Sonis 22 and Tavares 23 studies. In the study by Sonis [21], he used GAC brackets and light-cure composite. He found that SBS value was not statistically significant between control and sandblasted group. Between two recycling methods, aluminum oxide blasting method creates the highest bond strength. This better mechanical retention is mainly due to establishment of better microroughened surface of the bracket base. The smaller size of sand practices does not improve bonding strength. Some studies have used smaller particles and faced weaker bond strength due to the less surface roughness (the more polished surface) created by smaller sand particles. Some authors have found that sandblasting enhances bonding strength and thus recommends 3 minutes exposure of blasting particles to new brackets. This extra step benefits practitioners as well as patients for lessening bracket detachment occasions especially in low-compliant patients.

Several modifications were made in metallic brackets in order to reduce size and improve the bracket base because these variables influence the adhesion force. One of the modifications consists of pretreating the bracket bases using different procedures: sandblasting, micro etching and application of adhesive systems [24]. Bracket debonding is the most encountered complication during the orthodontic treatment.

Table 1: Mean shear bond strength (mpa) and standard deviation (sd) for each group after different recycling procedures

DEBONDING SEQUENCE	BOND STRENGTH (MEAN±SD)
One time sandblasting	48.6±3.59
Two time sandblasting	43±2.32
Thermal (heat) treatment	46±1.55
Hand piece	21±1.00
New brackets	54± 2.79

Table 2: Index of one-way ANOVA analysis for different groups

VALUE COMPARISON	SUM OF SQUARES	DEGREE OF FREEDOM	SQUARE MEAN	f-TEST	p-VALUE
Intergroups	3204.06	4	801.0151	2.866	0.169
Intragroups	86.49432	20	4.324716	-	-
Total	3290.555	24	-	-	-

Bracket debonding is the most encountered complication during the orthodontic treatment. Success rates depend on several factors such as the bonding agent employed, bonding technique, etching time, concentration of the etch, or features of the bracket base. Operator and patient factors also seem to influence the bond failure rate. The Operator factors include attention in clinical technique, choice of bonding material, contamination with saliva or improper application of primer on to the tooth surface. The patient factors include age and gender, type of malocclusion, hard sticky food, care taken of the appliance and biofilm layer. In this study the SBS values between the groups are not statistically significant. But the SBS value for the group using Hand piece as recycling method is very less and should not be preferred.

5. Conclusion

The shear bond strength of one-time sandblasting, thermal treated, two-time sandblasting and Hand piece groups are less than the newly bonded brackets. Although this difference is a clinical fact, it was not recognized statistically significant. Among the five methods, the one-time sandblasting and the thermal treated groups showed stronger bonding strength than the other two groups.

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