Shear Bond Strength of Metal Brackets Recycling with Aluminum Oxide

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Abstract: *Objective:* to evaluate the shear bond strength of metal brackets subjected to recycling with aluminum oxide.

Methods: 20 premolars were used, divided into two groups (n = 10) according to the brackets used (G1: Morelli® Light and G2: Morelli® Max). The teeth were autoclaved, included in ¾-inch PVC tubes, perpendicular to the ground. The brackets were fixed on the dental crowns with the Transbond™ XT kit (3M Unitek). The specimens were subjected to thermal cycling. The shear test was performed on the Instron® 5582 testing machine, at a speed of 0.5mm / min. The brackets were recycling with aluminum oxide 24 hours after the test. A new shear was performed, similar to the first. The buccal faces of the teeth were qualified through the IRA in both tests. The data were submitted to statistical analysis using the Kruskal-Wallis, ANOVA and Tukey tests (p <0.05).

Results: in the first shear, the bond strength values of Morelli® Max brackets (35,00MPa) were statistically higher than those of Morelli®Light (23,86MPa). In the second, the resistances were statistically similar (Morelli®Max: 37,19 MPa and Morelli®Light: 45,18 MPa). The Morelli® Light bracket was influenced by the recycling of aluminum oxide, with a significant increase in resistance from the first to the second test. There was no significance for the values of the IRA scores in both trials.

Conclusion: recycling with aluminum oxide influenced the shear bond strength of the Morelli®Light bracket, causing an increase in adhesion strength; the Morelli® Max bracket was superior to Morelli® Light before recycling; after recycling, the brackets had similar behaviors.

Keywords: Aluminum Oxide, Orthodontic brackets, Shear strength.

INTRODUCTION

The detachment of orthodontic accessories may be a consequence of factors such as flaws in the bonding technique, poor retentiveness of the bases, action of masticatory force and reduction in the size of these bases for aesthetic reasons. This rupture in the connection between bracket and tooth is a routine problem in the orthodontic clinic and results in delays in the time of clinical care, as well as an increase in the total time of orthodontic therapy [1, 2].

The success of direct bonding on dental enamel started with Newman [3], through a study that consecrated bracket bonding to the buccal surface of teeth. Until the 70s, the fixation of orthodontic accessories was performed by bandaging all teeth, which caused disadvantages such as: difficulty in cleaning, complexity, slowness of clinical execution and compromise of aesthetics. Thus, the direct bonding technique was an important advance for the development, simplification and expansion of fixed appliances [4, 5].

The evaluation of the bases of the brackets is important for the adhesion to the enamel, since the differences in conformation and retentions directly influence the values of bond strength to the dental substrate. According to these variations, the bases can have different degrees of retentivity [6].

The retention of orthodontic accessories can be enhanced with some resources such as micro sandblasting and the incorporation of metallic or ceramic particles. These actions aim to increase the resistance to detachment, decreasing the clinical adhesive failures [7, 8], which generate a detachment rate of orthodontic accessories, around 34% [6].

Recycling brackets, using aluminum oxide, is a simple technique that allows the cleaning of the bases of orthodontic accessories for re-bonding on teeth. Some studies [6, 8] report that blasting improves base retention, due to the formation of micro roughnesses that increase the surface area of contact with the adhesive system [1, 9].

Bearing in mind that aluminum oxide sandblasting is a practical and effective method, it is important to evaluate the effect of this processing on orthodontic accessories, in order to verify whether there is an influence of this procedure on the retentive capacity of brackets [7, 8].

Shear tests are one of the most common scientific ways to measure and evaluate the adhesiveness of

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restorative materials to dental tissues. One of the great advantages of the laboratory is the possibility of strict control of the research phases. Therefore, shear tests are a good method for evaluating recycled brackets [8, 10].

In view of the above, the objective of this study is to evaluate the shear bond strength of metal brackets subjected to recycling with aluminum oxide.

METHODS

This study followed the precepts of bioethics, being duly approved by the Research Ethics Committee of the Integrated College of Patos - UNIFIP / PB - Brazil, under PROTOCOL: 094/2012.

An *in vitro* experimental study was carried out, whose sample consisted of 20 healthy upper premolars, provided by the Bank of Teeth of UNIFIP / PB - Brazil. The teeth were cleaned with a soft bristle brush, without chemicals, in running water; and autoclaved in the Bioclave Device (12L Gnatus® Stainless Steel, Brazil) for 15 minutes, at 121°C, with the teeth immersed in distilled water. After this process, the teeth were stored in distilled water, under refrigeration, until the time of testing [11].

The materials selected for this study were: Transbond® XT kit (3M Unitek) and Morelli® Orthodontia Brackets - Brazil, models: Light (base formed by a retaining mesh welded to the bracket body, micro-sandblasted with increased roughness; area: 7,2mm²); and Max (base with micro pins that maximize the adhesion area and anchor the adhesive; area: 8,7mm²). The teeth were divided into two groups (n = 10), according to Table **1**.

The specimens were made including the teeth in PVC segments de inch in diameter and 25 mm high, with special stone plaster (Durone IV, Dentsplay®), in such a way that their crowns remained exposed and perpendicular to the base of PVC cylinders, and both perpendicular to the ground [11].

Prophylaxis was performed with extra-fine pumice (SS White®) and water, using a low-speed micro motor and contra-angle (Intra-matic 181 DBN - Kavo®) and rubber bowl (Microdont®), for 20 seconds. Then the teeth were conditioned with 37% phosphoric acid gel (Condac 37 FGM®) and the Transbond® XT kit adhesive (3M® Unitek) was applied, polymerized for 20 seconds (Optilight Max Gnatus®).

Transbond®XT Kit resin and adhesive were applied to the bases of the brackets, positioned over the center of the geometric crown of the teeth, and photopolymerized according to the times proposed by the manufacturers, 10 seconds on each bracket face (lateral, right and left; upper and lower), totaling 40 seconds [10].

After bonding, the specimens were stored in an oven at 37°C for 24 hours and subjected to 500 thermal cycles with 30 seconds in each bath (Biopdi® Machine) (5 °C and 55 °C). The specimens were coupled to the Universal Instron® 5582 testing machine (Model Mass, USA) and subjected to the shear test promoting the detachment of the brackets, at a speed of 0.5mm / min [12].

The buccal faces of the teeth were analyzed using a stereomicroscopic loupe (Model SMZ 745, Nikon®), with a 40-fold magnification [13] to detect the amount of adhesive remaining; and classified according to the Remaining Adhesive Index (IRA), proposed by Artun and Bergland [14], with scores from 0 to 3:

Score 0 = no adhesive residue was left on the tooth.

Score 1 = less than 50% of the adhesive was left on the tooth.

Score 2 = more than 50% of the adhesive was left on the tooth.

Table 1: Distribution of Groups According to the Type of Material Used

Groups	Bracket	Adhesive System
GROUP1	Bracket Morelli®Ligth Roth Slot 0.22 with hook	Kit Transbond® XT (3M® Unitek) (Adhesive 3M® Unitek)
GROUP 2	Bracket Morelli® Max Roth Slot 0.22 with hook	Kit Transbond® XT (3M® Unitek) (Adhesive 3M® Unitek)

Source: author's data.

Score 3 = all adhesive was left on the tooth.

For Test 2, the brackets were blasted with 50 µm aluminum oxide particles [12] (Micro-jet Plus - Bio-art®), for 15 to 30 seconds, depending on the amount of resin, keeping the distance of 20mm from the base of the bracket. The teeth were cleaned with multilaminated drills [10]. Base residues were removed by compressed air jets.

After cleaning the brackets, all the steps already described for Test 1 were repeated: prophylaxis on teeth; application of adhesive and resin on the brackets; and acid and adhesive conditioning on the teeth. Each bracket was retracted on the same tooth as in Test 1. Subsequently, autoclaving, cycling and a new shear test were performed. All procedures were repeated for Test 2.

The data obtained in Newtons (N) were transformed into Mega Pascal (MPa), according to the adhesion area, and were evaluated using the Statistica® Software, version 5.0, using the following tests: Kruskal-Wallis, ANOVA and Tukey, with 95% significance ($p < 0.05$).

RESULTS

The tables below describe the absolute and analytical values for the data found in the present research.

Table **2** describes the force values in MPa obtained for each sample during Test 1.

Table 2: Distribution of Force Values in MPa for Groups 1 and 2 (TEST 1)

Specimen	Group 1	Group 2
S1	30,8	50,52
S2	11,46	39,31
S3	17,25	29,94
S4	14,60	36,60
S5	23,26	39,20
S6	31,13	32,86
S7	23,49	36,06
S8	35,50	26,59
S9	24,23	33,94
S10	31,67	24,14

Source: author's data.

Table **3** describes the force values MPa obtained for each specimen during Test 2.

Table 3: Distribution of Force Values in MPa for Groups 1 and 2 (TEST 2)

Specimen	Group 1	Group 2
S1	21,03	36,06
S2	23,76	30,53
S3	27,79	33,36
S4	54,52	33,22
S5	45,38	41,46
S6	53,06	18,28
S7	44,98	38,32
S8	52,00	49,48
S9	45,94	41,19
S10	44,55	41,61

Source: author's data.

Table **4** describes the medians and the maximum and minimum values of the forces in MPa, for Tests 1 and 2. Analytical statistics with significance of 95% ($p < 0.05$) were applied.

Table 4: Distribution of Medians and Maximum and Minimum MPa of Shear Bond Strengths (TESTS 1 and 2)

Groups	Median	Minimum	Maximum	Comparisons
TEST 1				
G1	23,86	11,46	35,50	
G2	35,00	24,14	50,52	p<0,05, significant
TEST 2				
G1	45,18	21,03	54,52	
G2	37,19	18,28	49,48	p>0,05, no ignificant
G1 x G1 (T1)				p<0,05, significant
G2 x G2 (T2)				p>0,05, no significant

Source: author's data. (Tests: Kruskal-Wallis; ANOVA; Tukey).

Table **5** describes the IRA scores for groups 1 and 2, in Test 1. The highest frequencies were for Score 1 in Group 1 (50%); and for Score 0 in Group (70%). In the statistical analysis, no significant differences were found between the groups (Kruskal-Wallis p> 0.05).

Table 5: Distribution of IRA Scores in Groups 1 and 2 (TEST 1)

Specimen	Group 1	Group2
S1	1	1
S2	3	1
S3	0	0
S4	0	0
S5	3	0
S6	1	0
S7	1	0
S8	3	0
S9	1	0
S10	1	1

Source: author's data (Kruskal-Wallis p> 0.05).

Table **6** describes the IRA scores for groups 1 and 2, in Test 2. The highest frequencies were for Score 1 in Group 1 (50%); and for Score 0 in Group 2 (80%). In the statistical analysis, no significant differences were found between the groups (Kruskal-Wallis p> 0.05).

Table 6: Distribution of IRA Scores in Groups 1 and 2 (TEST 2)

Specimen	Group 1	Group 2
S1	0	0
S2	0	1
S3	0	0
S4	1	0
S5	3	1
S6	1	0
S7	1	0
S8	1	0
S9	1	0
S10	0	0

Source: author's data (Kruskal-Wallis p> 0.05).

DISCUSSION

The adhesion process is complex and involves the physical-chemical characteristics of the adhesive system, the dental substrate and the metallic mesh at the base of the bracket. In addition, the professional's technique must be developed correctly, according to the protocols of the manufacturers of dental materials, as well as the technical steps of restorative dentistry.

Laboratory studies aim to reproduce the existing conditions in the oral cavity, especially when it comes to tests with dental materials. One of the advantages of *in vitro* studies is the possibility of strict control of the variables that could interfere with the results [5, 7, 15].

Therefore, the shear bond resistance test has been used to investigate the adhesion of dental materials to the dental structure, and can be applied to the teeth of animals or humans, aiming to simulate the masticatory forces to which the orthodontic accessories will be exposed in the oral environment [15, 16].

The recycling bracket bases with aluminum oxide is a simple, low-cost technique that enhances the retention of adhesive material to the base of this accessory, according to some studies [17]. This method allows an efficient cleaning of the orthodontic devices, promoting the total removal of the adhesive materials after the detachment of the tooth. Thus, it is possible to re-attach the same accessory again, without loss in the adhesion process [12].

Literature [7, 12, 15, 18] reports shot recycling techniques with aluminum oxide with particles of varying sizes, including 50μm [18]. Comparative studies [2, 12] between the granulations suggest that there is no statistically significant difference between the particle sizes when used in the bracket base cleaning process.

Studies [15, 16] suggest that recycling with aluminum oxide can influence shear bond strength. This statement corroborates some of the findings of the present study, where the Morelli®Light brackets increased their resistance after the blasting process, as occurred in other studies [12]. The Morelli®Max bracket maintained its resistance before and after recycling, data similar to the findings of other studies [5, 7].

When comparing brackets, Morelli® Max obtained higher shear bond strengths than Morelli® Light, before and after recycling with aluminum oxide. This behavior may be due to the anatomical and size differences of the bases of these accessories [7]. Morelli® Max has a larger base (8,4mm²), with micro pins that maximize the adhesion area and anchoring to the adhesive; while the Morelli® Light has a smaller base (7,2mm²), formed by a retaining mesh welded to the bracket body, which receives recycling for increased roughness.

These data suggest that it is possible to use recycled brackets with adhesion results as reliable as those of new brackets, considering the materials studied and the parameters adopted in the present study. However, more research must be carried out so that the knowledge regarding the use of recycled orthodontic accessories is consolidated.

As for the IRA scores, it was observed that the scores of test 2 were reduced numerical, that is, a smaller amount of adhesive material was adhered to the enamel surface. This means that the bases of the brackets were more adherent after the recycling process [5, 8], an assertion that complements the significant results found for shear bond strengths. This reduction may be due to the increase in mechanical retentions formed by recycling at the bases of the brackets [5, 15].

Shear tests contribute to the quality control of dental materials available in the dental market [8]. However, it is advisable to always conduct them in such a way as to reproduce the possible clinical situations, because, although no laboratory test can satisfactorily predict the clinical behavior of a material, they can provide some indications regarding the quality and effectiveness of these products.

For this reason, it is suggested that more research be carried out in this regard, as well as that clinical research be added to laboratory ones. In this way, it will be possible to provide dentists with more safety and reliability when choosing their working material, as well as the patient will be able to enjoy scientifically proven and, consequently, more reliable and better quality treatment.

CONCLUSIONS

According to the applied methodology, the results discussed and the literature on the topic, it was concluded that:

- Recycling with aluminum oxide influenced the shear bond strength of the Morelli® Light bracket, increasing its adhesion;
- The shear bond strength of the Morelli® Max bracket was not influenced by recycling with aluminum oxide;
- The Morelli® Max bracket obtained greater shear bond resistance compared to the Morelli® Light bracket, before recycling with aluminum oxide. After recycling, the resistances were similar;
- There was no significant association between the IRA scores and the tests before and after recycling.

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