

Can 10% hydrofluoric acid be used for reconditioning of orthodontic brackets?

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ABSTRACT

Context: Bracket debonding is a common problem during orthodontic treatment. This type of failure is associated to masticatory forces, poor adhesion, and the need for repositioning the piece.

Aims: The objective of this work was to compare the shear bond strength of debonded brackets that were reconditioned using different protocols (alumina blasting versus hydrofluoric etching).

Settings and Design: This was an *in vitro* experimental study with 45 stainless steel orthodontic brackets.

Subjects and Methods: They were randomly divided into three groups: (1) New brackets ($n = 15$), (2) brackets reconditioned using 10% hydrofluoric acid for 60 s ($n = 15$), and (3) brackets reconditioned by aluminum oxide blasting until complete removal of the remaining resin ($n = 15$). In Groups 2 and 3, the insertion of composite resin proceeded in two stages to simulate a type of bracket failure in which the bonding resin was left at the bracket base. For the shear test, the assembly composed by the metallic support, and specimen was taken to the Instron universal testing machine in which the specimens were loaded using a semicircle-shaped active tip in the region of the bonding interface parallel to the surface of the bracket at a speed of 0.5 mm/min.

Statistical Analysis Used: The data were subjected to D'Agostino's normality test to have their distribution checked. Analysis of variance and Tukey's test ($P < 0.01$) were used to compare the findings between groups.

Results: The results indicated that Group 1 (new brackets) showed higher bond strength than that obtained for the group treated with hydrofluoric acid (Group 2, $P < 0.01$). The bond strength value obtained for the group treated with alumina blasting (Group 3) was statistically similar to those obtained for Groups 1 and 2.

Conclusions: The aluminum oxide blasting technique was effective for the reconditioning of orthodontic brackets. Nevertheless, the reconditioning technique using 10% fluoridric acid for 60 s was not efficient for clinical use.

Key words: Aluminum oxide, hydrofluoric acid, orthodontics

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Bracket failure or loss is a common clinical problem faced during orthodontic treatment,^[1-3] and accounts for 4.7–6% of the patients' complaints over a treatment period of 2 years.^[4] This type of clinical problem may occur due to accidental displacement related to occlusal trauma,^[5] excessive

overbite, or substrate contamination during bonding.^[6] Other factors related to these failures are bracket base design and type of adhesive.^[6] The brackets failure rates are also related to the type of tooth and its position in the arch, as it has been verified that incisors and canines show lower failure rates than premolars.^[7] Furthermore, lower canines are likely to present higher failure rates than those of their upper counterparts.^[8]

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Studies with metallic brackets evaluating bracket/resin/tooth bonding have reported that fracture usually occurs at the bracket/resin interface due to the weak bonding existing in this region.^[9,10] Higher fracture rates at the resin/tooth interface have been reported as a result of surface treatment before bonding^[3,11] or application of self-curing adhesive system.^[5]

In some cases, the clinician needs to decide how to proceed in cases of debonded and/or improperly positioned brackets.^[12] In such clinical situations, one needs to choose between using the original debonded bracket or a new one.^[5] If the debonded bracket is to be reused, it should go through a process known as reconditioning or recycling.^[13]

The primary goal of the reconditioning process is to remove the adhesive layer from the bracket retentive base without causing damages or distortions to the piece.^[12] This procedure can be done chairside (immediate method) or the bracket may be sent out to specialized companies, a procedure also known as commercial reconditioning (mediate method).^[4,12] One of the most popular and efficient chairside bracket reconditioning techniques is the aluminum oxide micromechanical blasting,^[12-18] and specific equipment needs to be acquired by the dentist for this technique. Commercial reconditioning has some disadvantages such as increased susceptibility to corrosion and the fact that it is time-consuming for routinely clinical practices.^[13]

Occasionally, in the absence of specific equipment and given the need for reconditioning the orthodontic bracket, the practitioner is supposed to find alternative methods to carry out this procedure. Hydrofluoric acid (HF) is a chemical agent that affects the composite surface morphology,^[19,20] and it is used in many procedures in dentistry. In repairs performed on resin composite restorations, HF is applied to create microretentions at the restoration surface to improve bonding between the old and the new composite materials.^[20]

HF has shown promising results when used in the repair of resin composites or cementation of indirect resin restorations.^[20] However, there are doubts in relation to the use of HF to improve the bonding of debonded brackets to dental enamel. Thus, the effectiveness of HF etching on the bond strength of debonded metallic brackets needs to be further investigated. The objective of this work was to compare the shear bond strength of debonded brackets that were reconditioned using different protocols (alumina blasting versus HF etching). Our hypothesis was that HF etching would result in higher bond strength values than alumina blasting for debonded brackets.

SUBJECTS AND METHODS

Preparation of specimens

This was an *in vitro* experimental study with 45 stainless steel orthodontic brackets designed for right maxillary

central incisors, Roth prescription (3M Abzil, São José do Rio Preto, SP, Brazil), which were divided into three groups:

Group 1: Fifteen new brackets (control group); Group 2: Fifteen brackets reconditioned with a porcelain conditioner, 10% fluoridric acid (Porcelain Conditioner, Dentsply®, Petrópolis, RJ, Brazil); Group 3: Fifteen brackets reconditioned by aluminum oxide blasting (Jat bracket, VH Equipment®, Araraquara, SP, Brazil).

Specimens were prepared using a cylindrical polyvinyl chloride (PVC) tube (Tigre®, Joinville, SC, Brazil) measuring $\frac{3}{4}$ inch in diameter and 3 cm in height to serve as a matrix, allowing for the formation of resin cylinders as described in a previous study by Mondelli and Feitas.^[10]

The brackets were positioned on a tape with their base (retentive mesh) facing the sticky side. After placing the bracket on the tape, the PVC tube was positioned over it so that the bracket was at the center of the pipe, as shown in Figure 1a. Chemically activated acrylic resin (JET®, São Paulo, SP, Brazil) was then poured into the pipe. After the setting time of acrylic resin was completed, the adhesive tape was removed, resulting in a specimen containing the bracket base available for the bonding procedure.

Before the experimental tests, the brackets bases were subjected to prophylaxis using Robson brush with pumice in a low-speed micromotor. These were washed with jets of air and water for 30 s and then dried with jets of air for the same time.^[10]

Test groups

Each experimental group was submitted to one of the following treatments. In Group 1, after the brackets had been stabilized and cleaned, a self-sticking adhesive with a central hole of 3 mm in diameter was applied on the specimen surface so that only the bracket base was exposed [Figure 1b]. For standardization of the application of composite resin on the bracket base, a metallic device and a split Teflon mold were adapted to the PVC cylinder, as shown in Figure 1c. This device consists of a metallic structure with a lateral screw and a split Teflon mold, having a central hole with a diameter of 3 mm and 2 mm in height. A commercial composite resin (3M Unitek®-Transbond XT, Monrovia, CA, USA) was then applied to the bracket base and photoactivated by a light-emitting diode (LED) device (SDI® – Radium™, Bayswater, Victoria, Australia) for 40 s with intensity of 400 mW/cm², as measured by a radiometer (Gnatus®, Ribeirão Preto, SP, Brazil) for LED devices. All specimens were carefully removed from the Teflon mold and metallic bases. The prepared specimens were stored in distilled water for 24 h at 37°C.^[19]

In Groups 2 and 3, the insertion of composite resin proceeded in two stages to simulate a type of bracket failure in which

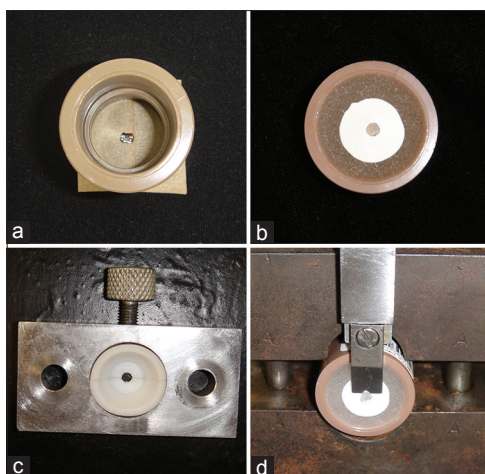


Figure 1: (a) Polyvinyl chloride pipe centralized in relation to the bracket. (b) Self-sticking adhesive on the specimen surface. (c) Metallic support with Teflon mold adapted. Note the central hole, which has dimensions equal to those of the self-sticking adhesive in the specimen. (d) Specimen undergoing the shear test. Note the semicircle-shaped active tip adapted to the specimen to exert continued strength aimed to break down the specimen

the bonding resin was left at the bracket base. The applied resin composite covered the entire bracket base surface with a uniform thickness of 1 mm.

Specimens were stored in a container with distilled water for 24 h, as proposed by Endo *et al.*^[19] Subsequently, the reconditioning process was preceded as described below:

Group 2: Removal of the composite resin from the bracket base by means of a silicon carbide abrasive flap disc, without hitting the metallic mesh. The bracket base was washed and dried with a jet of air and water using a triple syringe for 30 s. After that, 10% hydrofluoric acid was applied for 60 s, with subsequent washing and drying for 30 s.

Group 3: Reconditioning was made with aluminum oxide blasting with 90 μ m particles placed 10 mm away from the bracket base. The blasting pressure was set at 80 psi. After that, the brackets were washed with water and air-sprayed for 30 s and then completely dried.

After the reconditioning stage, the resin composite was applied using a metallic support and Teflon mold, as described for Group 1, for subsequent shear testing.

Shear test

Each specimen was placed individually on a metallic support containing a hole, which had two screws used to adjust the cylinder and keep it still. The assembly composed by the metallic support, and specimen was taken to the Instron universal testing machine (Instron Corp.[®], Model 4444, Canton, MA, USA), in which the specimens were loaded using a semicircle-shaped active tip in the region of the

bonding interface parallel to the surface of the bracket at a speed of 0.5 mm/min [Figure 1d]. The values were recorded in kilonewtons, and bond strength (megapascal [MPa]) was calculated thereafter.

Statistical analysis

Data were submitted to statistical analysis with the software BioEstat 5.0 (BioEstat[®] Software, Belém, PA, Brazil). The sample size was calculated considering a 5% alpha error, significant differences between groups of 2.0 MPa, and standard deviation of 2.03 MPa. These values were obtained from a previous study^[10] and confirmed with the present investigation. Therefore, with a sample size of 13 specimens, the power of this study was calculated to be 95%. Intergroup values were submitted to a normality test (D'Agostino test). As values were found to have a normal distribution, they were analyzed by one-way analysis of variance (ANOVA test, $P < 0.0001$) followed by Tukey–Kramer multiple comparison test ($P < 0.01$) between groups.

RESULTS

The mean shear strength values and standard deviations for the three experimental groups are shown in Table 1 and Figure 2. The results indicated that Group 1 (new brackets) showed higher bond strength than that obtained for the group treated with hydrofluoric acid (Group 2, $P < 0.01$). The bond strength value obtained for the group treated with alumina blasting (Group 3) was statistically similar to those obtained for Groups 1 and 2.

DISCUSSION

The shear test performed in this study has been also described by other authors,^[1,21–24] and the load was applied in the occlusolingival direction since a greater resistance would be expected if this test had been carried out in the mesiodistal direction because of the greater dimension of the bracket. Moreover, the load applied on the occlusolingival direction seems to better simulate the way, these brackets are loaded in the oral cavity.

Several studies^[9–11] have shown that considering the bracket/resin/tooth interrelationship; fracture normally occurs at the bracket/resin interface because the adhesive bonding existing in this area is weak. However, studies investigating bracket reconditioning commonly assess bond strength to the tooth structure.^[1–3,6,25] In the present study, the methodology used allowed for the evaluation of the bracket/resin interface. With regard to the bracket reconditioning process, a more critical clinical situation was simulated, for example, permanence of remaining resin on the base of the orthodontic accessory. Hence, the findings reported here in should be interpreted carefully when compared to those of other studies.

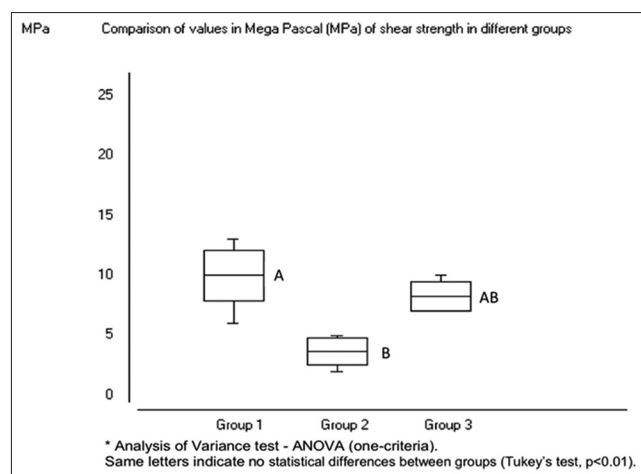


Figure 2: Comparison of the values in megapascal of shear strength in different groups *Significance of 5%. Analysis of variance test – ANOVA (one-criteria). Same letters indicate no statistical differences between groups (Tukey's test, $P < 0.01$)

Table 1: Distribution of values (mean±standard deviation) expressed as megapascal regarding shear strength in different groups

Study groups	Mean±SD
Group 1	10.54±2.03 ^A
Group 2	4.17±1.05 ^B
Group 3	8.83±1.21 ^{A,B}
P*	0.0001

*ANOVA test (one-criterion). Same letters indicate no statistical differences between groups (Tukey's test, $P < 0.01$). SD=Standard deviation, ANOVA=Analysis of variance

The bond strength results found for Group 1 (control) and Group 3 (aluminum oxide blasting) are in the range compatible with clinical use because to withstand the forces exerted by the arch on the tooth during orthodontic treatment, there should be a minimum shear strength varying from 5 to 8 MPa.^[4,26,27] On the other hand, the brackets that were reconditioned using hydrofluoric acid showed a statistically lower performance than those of other groups. In addition, these etched brackets showed shear strength values below the threshold for a good clinical performance, contradicting the hypothesis of this study. This finding could be explained due to the large amount of remaining resin on the bracket base. When there is a significant amount of resin composite left on the bracket base after debonding (as simulated in the current investigation before reconditioning), there are lower chances of achieving good bond strength results.^[28] In addition, the contact time between the hydrofluoric acid and the remaining resin may have been insufficient to cause microretentions in the resin surface.

A number of studies have shown that aluminum oxide blasting is the most effective technique to remove the remaining resin from the bracket base. Accordingly, this surface treatment has been the most indicated technique for reconditioning^[12-18] corroborating the results found in the

current study. Quick *et al.*^[13] found shear strength values of 7.28 MPa (± 1.58) for brackets reconditioned using this technique. In the present study, a slightly higher shear strength values 8.83 (± 1.21) MPa was found.

Techniques that employ abrasive tips or multilaminated drills to remove the remaining resin from the bracket base should be analyzed carefully. Quick *et al.*^[13] did not find good bond strength results for these techniques. In the current investigation, the remaining resin was partially removed by means of a silicon carbide abrasive tip before etching. As a result, a resin layer remained on the bracket mesh with the purpose of preventing its base to be altered by the abrasive tip. Egan *et al.*^[6] proposed that these techniques may have clinical effects on the brackets torque, rotation, and “in/out” parameters. The magnitude of these changes due to the additional resin layer should be evaluated along with the magnitude of natural variation in the structure of the buccal surfaces of the teeth.

In the present study, brackets that underwent reconditioning showed shear strength values lower than those obtained for new brackets, confirming the findings of other studies.^[5,12,25] Quick *et al.*^[13] had similar results for various reconditioning approaches, but when using aluminum oxide blasting, they observed no significant decrease in shear strength values. Likewise, Montasser *et al.*^[3] observed no difference in the clinical performance of three adhesive systems in reconditioning procedures.

Although hydrofluoric acid has been proven to be effective in repairing composite resin and to prepare indirect restorations,^[20,29,30] this acid was not effective in the reconditioning of orthodontic brackets. Therefore, its use is not indicated for this purpose at a concentration of 10% for 60 s because it may result in clinical failures for reused orthodontic brackets, as these accessories would not have sufficient strength to withstand masticatory loads and forces applied during orthodontic movements.

Thus, in case of bracket bonding failure, it is recommended as first-choice of clinical protocol to use a new bracket, but if this is not possible, one should consider the reconditioning with aluminum oxide blasting. Further studies are needed to test this technique using different concentrations of hydrofluoric acid as well as different time protocols.

CONCLUSIONS

According to the conditions and shortcomings of this *in vitro* study, it could be concluded that the aluminum oxide blasting technique was effective for the reconditioning of orthodontic brackets. Nevertheless, the reconditioning technique using 10% hydrofluoric acid for 60 s was not efficient for clinical use.

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Conflicts of interest

There are no conflicts of interest.

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