

ANALYSIS OF THE BOND STRENGTH OBTAINED IN SHEAR AND SHEAR-PEEL TESTING OF ORTHODONTIC BRACKETS

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Abstract. *The purpose of this study was to evaluate the bond strength of orthodontics brackets using two techniques: shear and shear-peel. Recently extracted bovine mandibular incisors were randomly divided into 2 groups according testing: shear (Group 1) and shear-peel (Group 2). Each group was subdivided into 2 subgroups: in the first one, samples were stored in distilled water (37°C) for one week before testing and in the second, they are not stored. Teeth were rinsed, cut with a saw and embedded in self-curing acrylic resin. Then orthodontics brackets were bonded with cement in enamel according to the manufacturer's instructions. Mechanical tests (shear-peel and shear) were realized in a universal testing machine. Samples were maintained in vertical position using a jig so that the bracket base of the sample remained parallel to the force application. For shear-peel, orthodontic stainless steel wire was attached to the bracket and connected to the machine. A tension force was applied and the maximum load necessary to debond was recorded. For shear testing, compression force was applied to the bracket-tooth interface with a punch and the maximum load necessary to debond was recorded. The results indicate that group 2 showed significantly higher than bond strength values than group 1. Shear-peel appears to be a reasonable method for to evaluate bond strength in orthodontics brackets.*

Keywords: *bond strength, orthodontic brackets, shear, shear-peel*

1. INTRODUCTION

Orthodontic therapy involves the use of metal appliances, which are fixed to the teeth during treatment. The components of these appliances are brackets, molar bands and archwires. Metal and alloys have been used in orthodontics bracket manufacture include stainless steel (AISI types 303, 304, 316, 316L and 317) and nickel-titanium (Nitinol). Stainless steel contain from 8% to 12% nickel and 17-22% chromium are used (Kao et al., 2002; Locci et al, 2000).

Brackets are bonded to teeth using retentive materials such as composite resin and primers. However, the unplanned debonding of brackets is a common occurrence among orthodontics patients. According Sorel et al.(2002) bracket bond strength depends on several factors: type of bracket retention mechanisms, bonding system and type of enamel conditioner.

Efforts have been made to improve mechanical retention with various designs. Blalock and Powers (1995) evaluated four types of brackets (stainless steel, polycarbonate, ceramic and ceramic-polycarbonate). For the metal bracket, all failures occurred at the bracket/cement interface. For others brackets, failures at the bracket/cement interface were 94% for polycarbonate bracket, 88% for the ceramic brackets and 49% for the ceramic/polycarbonate bracket. Sharma-Sayal e tal. (2003) evaluated six types of brackets with different bases. The authors concluded that bracket base design significantly influences in shear bond strength and that brackets with a 60-gauge foil-mesh or an integral undercut machined base achieve higher bond strength.

Also for improve chemical retention, new adhesives e composites resins have been evaluated. Recently, Chitnis et al. (2006) compared shear bond strength using four adhesives: giomer material, polyacid-modified composite resin, resin-modified glass ionomer and a standard resin-based composite. Under the conditions of this in vitro study, they were concluded that conventional cement and resin-modified glass ionomer showed significantly higher orthodontic bond strength than composite resin and giomer material.

Several in vitro studies have been realized to evaluate orthodontic bonding with new brackets and adhesives materials. In mouth, bracket is subjected to loads (forces and moments) that act in all directions with a wide range of magnitudes and durations. Thus, is very difficult to replicate these conditions in laboratory (Gibb and Katona, 2006). The mode of testing varies between studies, but generally brackets are debonded with shear or shear-peel forces. In shear strength force is applied parallel to the sample in the interface bracket-tooth while in shear-peel testing the force is applied in several directions with a stainless steel wire.

It has been recognized that direction of the debonding force will affect the results (Klocke and Nieke, 2006). In 1997, Stanford, Wozniak and Fan presented an informative review about standardization in orthodontic testing. Many problems were detected such as: rates of loading, distance between shear force application and the substrate surface,

among others things. In other study, Littlewood and Redhead (1998) evaluated the use of jigs for in vitro orthodontic bond strength testing helped to standardize the technique. Two jigs were developed and they authors concluded that was possible reduce variations in results.

For the reasons shown, the purpose of this study in-vitro was evaluated retentive capacity of brackets using two techniques: shear and shear-peel.

2. MATERIALS AND METHODS

Twenty freshly bovine incisors teeth obtained from slaughterhouse were used in this study. Teeth were extracted of mandibles and coronal pulps removed with a precision saw (IsoMet 1000, Buehler, USA) (Figure 1).



(a)



(b)

Figure 1 – (a) Bovine mandible; (b) Cut-off a crown with a diamond wafering blade

Crowns were embedded in autopolymerizing polymethyl methacrylate (PMMA) in plastic cylinders (25 mm diameter and 20mm of high) to allow secure placement during testing. Facial surface of each tooth was maintained above of PMMA and perpendicular to cylinder (Figure 2).

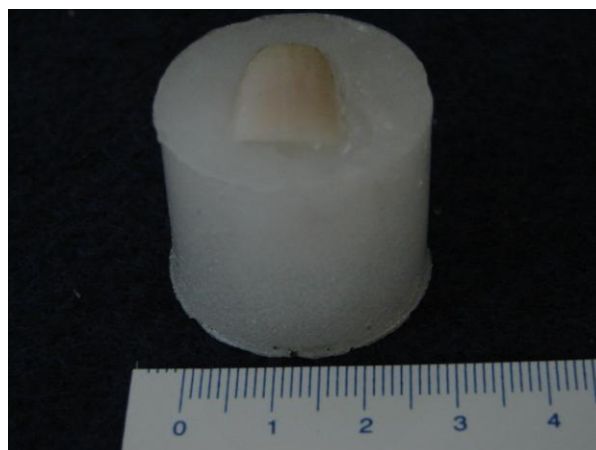


Figure 2 – Tooth embedded in autopolymerizing polymethyl methacrylate

After polymerization of resin, surface of embedded teeth were cleaned with distilled water and dried with cool air. Then, surfaces were etched with a 37% phosphoric acid gel for 40 seconds and washed under running distilled water for 60 seconds. Primer was applied in conditioned surface and light-cured composite resin (Transbond XT) was placed on the bracket base in accordance with the manufacturers' instructions. Stainless steel premolar brackets (0.022-in Abzil) with resin were bonded in teeth using a jig to allow uniform placement of each bracket (Figure 3 and Figure 4).

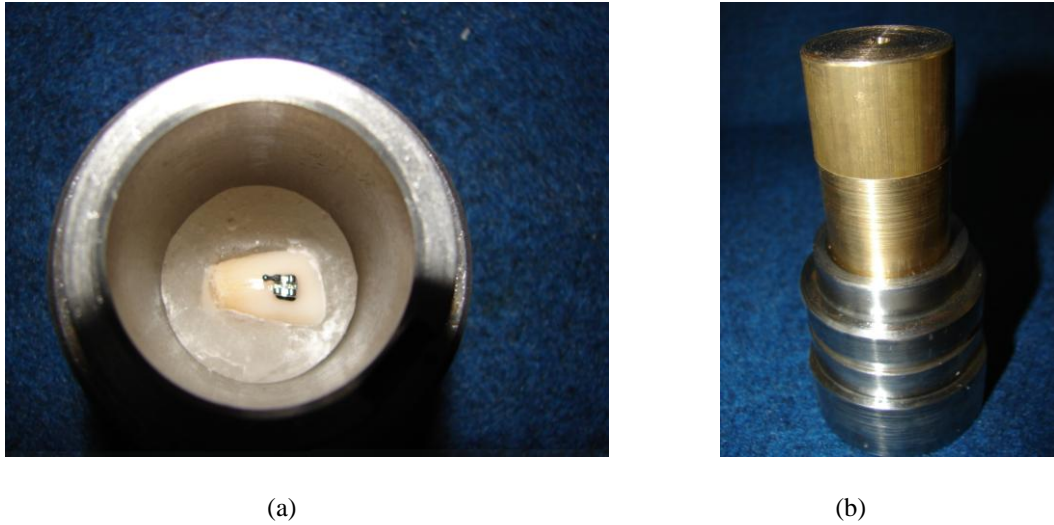


Figure 3 – (a) (b) Bonding jig designed

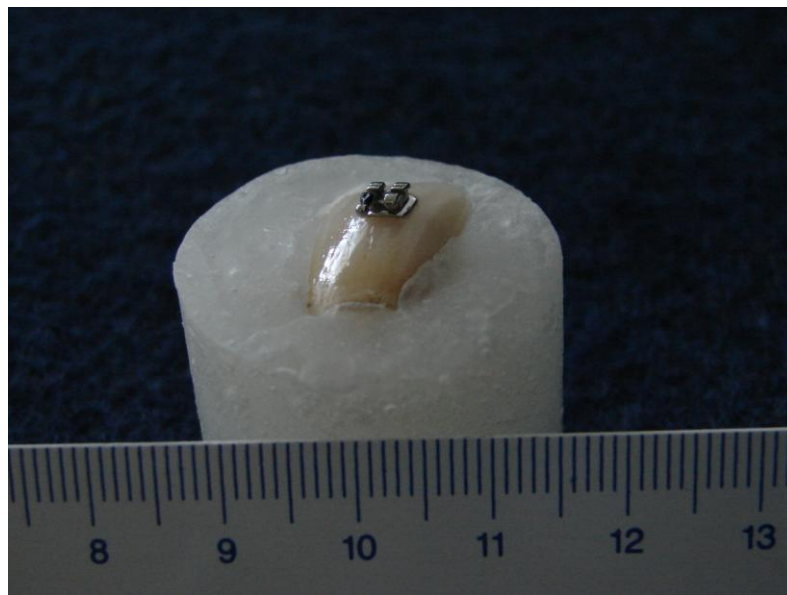


Figure 4 – Type of sample used in tests

The specimens were randomly divided into two groups: shear (Group 1) and shear-peel (Group 2). Each group was subdivided into two subgroups according storage: without stored (24h) or stored in distilled water at 37°C for seven days before testing. These media were chosen based in Titley et al. (1998) research.

An universal testing machine (Emic, Brazil) was used to perform the shear and shear peel bond strength tests. The crosshead speed was fixed at 1mm/min. Samples were maintained in vertical position using a jig so that the bracket base of the sample remained parallel to the force application according proposed by Gibb and Katona (2006).

In shear, brackets were tested to failure by a tool (punch) mounted on the crosshead of the testing machine and load was applied to the bracket-tooth interface. For shear-peel, orthodontic stainless steel wire was attached to the bracket and connected to the machine (Figure 5). A tension force was applied and the maximum load necessary to debond was recorded. For shear testing, compression force was applied to the bracket-tooth interface with a punch and the maximum load necessary to debond was recorded.

Shear bond strength was calculated by dividing the force by area of the bracket area. The average bracket base surface area was 10.66mm². Means and standard deviations of the shear bond strength were calculated for the experimental groups. For each debonding method, a t-student was used to test for differences in mean debonding according stored media.

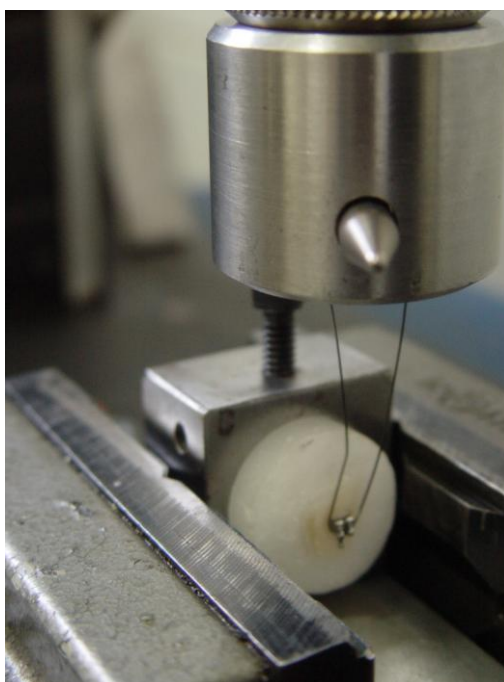


Figure 5 – Specimen under shear-peel loading

3. RESULTS

The mean shear bond strength and their standard deviations are showed in Table 1. The data showed no significant differences ($P < 0,05$) between the subgroups for each stored media. However significant differences were revealed between debonding methods. The results indicate that Group 2 (16.91) showed significantly higher than bond strength values than Group 1 (10.40MPa). Shear-peel appears to be a reasonable method for to evaluate bond strength in orthodontics brackets.

Table 1. Shear bond strength data

Group		Mean (MPa)	SD
SHEAR	24h	11.62	2.41
	stored in water for 7 days	10.40	1.26
SHEAR-PEEL	24h	15.85	3.24
	stored in water for 7 days	16.91	4.26

4. DISCUSSION

During orthodontic therapy, brackets are exposed to loads that act in all directions with a wide range of magnitudes. Shear peel and shear are the predominant loading modes used in vitro testing. Thus, the purpose of this work was evaluated these testing.

In our methodology, bovines' teeth were used in testing. Bovine enamel has been reported to be a substitute for human enamel with no statistically significant difference (Oesterle et al., 1998). Samples were prepared according literature (MacCool et al, 1998; Chitnis et al. 2006). Teeth were decoronated and crowns were embedded in autopolymerizing resin with facial surface of each tooth was maintained above of resin and parallel to horizontal.

Our results are consistent with those of Titley et al. (1998) and show no statistically difference in mean bond strength between storage media (distilled water) and room temperature for subgroups. Otherwise, results indicate that group 2(shear-peel) showed significantly higher than bond strength values than group 1(shear). One possible reason for the difference between bond strength values is the mode of the load application. In shear, brackets were tested to failure by a tool (punch) mounted on the crosshead of the testing machine and load was applied to the bracket-tooth interface. In shear-peel, specimens were debonded using a stainless steel wire.

5. CONCLUSIONS

The present study showed that variations in storage media for the same testing do not have a significant influence on debonding forces. Otherwise, results indicate significant differences between tests evaluated, shear-peel showed significantly higher than bond strength values than shear. Thus, shear-peel appears to be a reasonable method for to evaluate bond strength in orthodontics brackets.

6. ACKNOWLEDGEMENTS

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8. RESPONSIBILITY NOTICE

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