Shear Bond Strength of Brackets Bonded with Two Light-curing Orthodontic Adhesives

Rowan V. Vilar[a]/Nathaly F. Souza[a]/Julio P. Cal-Neto[b]/Myrela Galvão[c]/Hélio Sampaio-Filho[d]/Alvaro de Moraes Mendes[e]

Purpose: To compare the shear bond strength of stainless steel brackets bonded with two orthodontic adhesive systems, Transbond XT (3M Unitek) and Orthobond (Morelli Dental Products).

Materials and Methods: Forty bovine teeth were randomly divided in two groups of 20 each: group 1 (control): Transbond XT primer + Transbond XT Adhesive paste (3M Unitek); group 2: Orthoprimer (Morelli Dental Products) + Orthobond. In each group all teeth were etched with 37% phosphoric acid, and all products were used according to manufacturers instructions. After 30 min, a universal testing machine was used to apply an occlusal shear force directly to the enamel/bracket interface at a speed of 0.5 mm/min. The groups were compared using Student's t-test.

Results: Mean results and standard deviations for the groups were: group 1= 11.22 Mpa (1.68), group 2= 4.88 Mpa (1.18). A significant difference was observed in the bond strengths of the two groups evaluated ($p < 0.0001$).

Conclusion: Under the conditions of this study, Orthobond system presented lower shear bond strength when compared to Transbond XT.

Keywords: acid etching, bonding, brackets, orthodontics.

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The presentation of the acid-etching technique by Buonocore[4] and the development of adhesive materials has lead to significant advances in many fields of dentistry. One of these advances was the possibility to bond orthodontic attachments directly to enamel, described by Sadler[25] and Newman,[19] gradually replacing the band-based treatments.

Many materials have been used in orthodontic bonding procedures, but light-cured composite resins still are the most popular ones. Light-cured composite resins systems provide ample time to accurately position the bracket on the tooth, remove excess adhesive before polymerization, and provide sufficient bond strength values.[1]

The bond strength of adhesive and attachments should be sufficient to withstand all forces and stresses exerted by mastication and archwires. Although there is no formally accepted minimum clinical bond strength, various studies have mentioned bond strengths ranging from 5 MPa to 10 MPa[12,15,16,24] as being adequate for clinical situations.

The purpose of this study was to compare the shear bond strength and adhesive remnant index (ARI) of orthodontic brackets bonded to enamel with a conventional orthodontic adhesive system, Transbond XT (3M, Unitek; Monróvia, CA, USA) and a recently developed one, Orthobond (Dental Morelli; São Paulo, Brazil). The null hypothesis to be tested is that there is no difference in the mean shear bond strength between the use of the conventional bonding system and the recently developed one.

MATERIALS AND METHODS

Material

A total of forty bovine incisors was collected and stored in a solution of 0.1% thymol at room temperature until time

[a] *Undergraduate Student, School of Dentistry, State University of Rio de Janeiro, Rio de Janeiro, Brazil.*

[b] *Professor, Department of Orthodontics, Fluminense Federal University, Nova Friburgo, Rio de Janeiro, Brazil.*

[c] *PhD Student, Department of Orthodontics, State University of Rio de Janeiro, Rio de Janeiro, Brazil.*

[d] *Professor, Department of Restorative Dentistry, State University of Rio de Janeiro, Rio de Janeiro, Brazil.*

[e] *Professor, Department of Orthodontics, State University of Rio de Janeiro, Rio de Janeiro, Brazil.*

Correspondence: *Julio Pedra e Cal-Neto, Fluminense Federal University – UFF, Rua Dr. Sílvio Henrique Braune 22, Centro, Nova Friburgo-RJ, Brasil Cep: 24020-420. Tel: +55-22-252-87168, Fax: +55-22-252-87168. e-mail: juliocalneto@yahoo.com.br*

of use (approximately 2 months). Other studies concluded that bovine teeth can be used as a substitute for human teeth in adhesion tests.[17,20] Teeth with cracks, fractures, hypoplasic enamel or any kind of enamel surface defect were excluded.

Each tooth was sectioned below the cementoenamel junction and the crowns were mounted in plastic rings with acrylic resin. The crowns were oriented so that the labial enamel surface would be parallel to the force during the shear strength test. After complete polymerization, the specimens were polished to remove acrylic overflow and to standardize enamel rugosity. The labial surfaces were cleaned and polished with a rubber cup and pumice, followed by rinsing with water spray and drying with compressed air.

Bonding Procedure

Stainless steel maxillary central incisor brackets (Dental Morelli; São Paulo, Brazil) were used in this study. The average bracket base surface area was determined to be 14.22 mm^2 The teeth were randomly divided into two groups, and brackets were bonded according to the manufacturer's instructions following one of the two protocols:

- Group 1 (control group): Teeth were etched with 37% phosphoric acid. The orthodontic brackets were bonded with Transbond XT Primer and adhesive paste (3M Unitek).
- Group 2: Teeth were etched with 37% phosphoric acid. The orthodontic brackets were bonded with Orthoprimer and Orthobond (Dental Morelli).

The bracket was firmly seated on the tooth surface, minimizing the resin film thickness. A small dental probe was used to carefully remove the excess from around the bracket. Each bracket was light polymerized with Ortholux XT (3M Unitek), a halogen-based visible-light-curing unit for 10 s distally and 10 s mesially. After bonding, the specimens were stored in distilled water at room temperature.

Testing Procedure

The bracket/tooth interface for each specimen was tested after 30 min in shear with a sharp, chisel-shaped rod attached to a universal testing machine (EMIC MF DL 500; Paraná, Brazil) at a crosshead speed of 0.5 mm/min until bracket failure. The edge of the chisel was carefully positioned at the interface of the tooth and bracket. The force in Newtons was recorded for each specimen and divided by the surface area of the bracket pad to obtain the shear stress value in MPa.

After debonding, the teeth and brackets were examined under 10X magnification (Olympus Optical; Hamburg, Germany) to evaluate the amount of resin remaining on the tooth. The adhesive remnant index (ARI)[2] was used to describe the quantity of resin remaining on the tooth surfaces. The ARI score has a range between 0 and 3 as follows: 0 indicates that no composite remained on the enamel; 1, less than 50% of composite remained on the tooth surface; 2, more than 50% of the composite remained on the tooth; 2, 100% of the composite remained; and 3, all of the composite, as well as the impression of the bracket base, remained on the tooth.

Statistical Analysis

Descriptive statistics, including the mean, standard deviation, and minimum and maximum values, were calculated for each group tested. The data of bond strength were tested for normality with the Shapiro-Wilk method. The Student's t-test was used to determine whether significant differences were present in the bond strength between groups. The chi-square test was used to evaluate differences in the ARI scores between groups. All statistical analyses were performed with the software Prism 4.0 (GraphPad Software; San Diego, CA, USA) at a 5% level of significance.

RESULTS

The descriptive statistics comparing the shear strength of the two groups are shown in Table 1. The Student's t-test showed significant differences ($p < 0.0001$) between the groups evaluated. The Orthobond group had a mean shear bond strength of 4.88 ± 1.18 MPa, whereas the control group had a mean of 11.22 ± 1.68 MPa (Fig 1).

The ARI scores for the two groups tested are listed in Table 2. The results of chi-square comparisons for the ARI indicated that there was a significant difference ($p < 0.0001$) between the group that was bonded with Orthobond compared with the control group.

DISCUSSION

The null hypothesis tested was rejected. The results indicated that the shear bond strength of brackets bonded with Transbond XT system was higher than the debond value of brackets bonded with Orthobond. The mean values for the control group are in agreement with previous studies.[5,7,21,22]

The bonding system used must be able to resist to the different and constant forces during mastication and orthodontic mechanotherapy. Currently, there is no universally accepted minimum clinical bond strength, and it will vary depending on such factors as enamel morphology, bracket base design, appliance force systems, and clinician's technique.[10] In this study, bracket failure occurred between 4.88 and 11.22 MPa. High values of bond strength might not be the most desirable characteristic, because brackets will be removed at the end of treatment and clinical problems with enamel cracks could occur.[6,8,13,14] According to Retief,[23] enamel fractures in vitro can be observed on specimens with bond strength values as low as 9.7 MPa.

The evaluation of the ARI scores indicated significant difference in bond failure site among the two groups. These results showed that brackets bonded with Transbond XT left less adhesive on the enamel than when Orthobond was used. This fact may be disadvantageous for clinicians, because bond failure at the bracket/adhesive interface or within the adhesive is more desirable than at the adhesive/enamel interface, in order to avoid enamel fracture at time of debonding.[8,13]

Table 1 Results of Student's t-test comparing shear bond strengths (MPa) of experimental groups

Groups tested	n	Mean*	SD	Range
1. Transbond XT primer + adhesive paste	20	11.22	1.68	8.90-14.68
2. Orthoprimer + Orthobond	20	4.88	1.18	2.92-7.21

* Statistically significant differences between groups were observed ($p < 0.0001$; $t = 13.80$).

Table 2 Frequency distribution and results of chi-square analysis of the ARI of the groups

		ARI scores* #			
Groups tested	n	0	1	2	3
1. Transbond XT primer + adhesive paste	20	9	6	3	2
2. Orthoprimer + Orthobond	20	0	0	1	19

* ARI: adhesive renant index. 0, no adhesive remaining on tooth; 1, less than half of enamel bonding site covered with adhesive; 2, more than half of enamel bonding site covered with adhesive; 3, enamel bonding site covered entirely with adhesive. #χ^2=29.76, statistically significant differences were observed ($p < 0.0001$).

Among all in vivo and in vitro studies, bonds strength tests have shown wide variation.[3,9] Pickett et al[22] found that the bond strengths in vivo were significantly lower than those measured in vitro. Another in vitro study[11] that examined the bond strength between glass ionomers and enamel yielded values twice as high as in vivo measurements under nominally identical experimental conditions.

From a clinical standpoint, the use of the Orthobond system needs to be carefully evaluated due to its lower shear bond strength when compared to a standard adhesive system. However, according to some authors, the orthodontic force applied to brackets during treatment is between 1 and 3 MPa.[18] Nevertheless, this was a laboratory study and care should be taken in interpreting the results. In order to recommend large-scale use of this product, more studies are required, particularly in vivo studies and clinical trials.

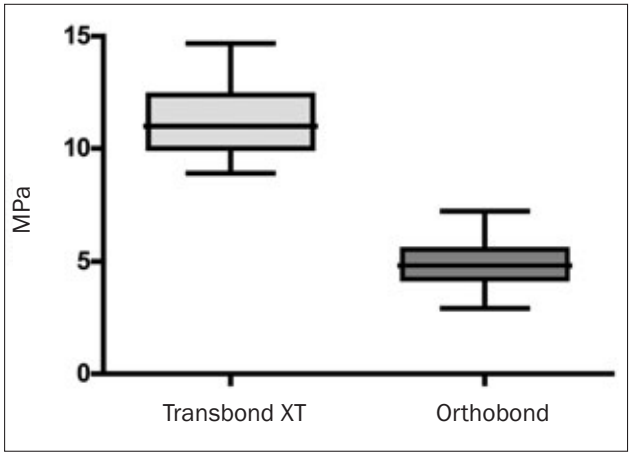

Fig 1 Box plots for shear bond strength (MPa) of experimental groups.

CONCLUSIONS

Under the conditions of this study, the Orthobond system presented lower shear bond strength than did Transbond XT. The amount of adhesive on enamel after debonding was significantly higher when using the Orthobond system.

Care should be taken to recommend the use of the Orthobond system due to the lack of agreement among authors about the minimum clinical shear bond strength required to withstand orthodontic and masticatory forces and stresses.

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Clinical relevance: Orthobond has been used in orthodontic bonding procedures, and this study was useful to provide initial data about this product, which presented lower shear bond strength than Transbond XT.