# Evaluation of the shear bond strength of two composites bonded to conditioned surface with self-etching primer

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## Abstract

**Aim:** The aim of this study was to evaluate the shear bond strength and the Adhesive Remnant Index (ARI) between the composites Eagle Bond and Orthobond bonded to an enamel surface conditioned with Transbond Plus Self-Etching Primer. **Methods:** Seventy-five bovine permanent mandibular incisors, divided into five groups (n=15) were used. In Groups 1, 2 and 4, the bonds were performed with Transbond XT, Orthobond and Eagle Bond respectively, in accordance with the manufacturers' recommendations. In Groups 3 and 4, before bonding with Orthobond and Eagle Bond, respectively, the tooth surface was conditioned with the acid primer Transbond Plus Self-Etching Primer. After bonding the shear test was performed of all samples at a speed of 0.5 mm per minute in an Instron mechanical test machine. **Results:** The results (MPa) showed that there were no statistically significant differences among Groups 1, 2, 3 and 5 ($p>0.05$). However, these groups were statistically superior to Group 4 ($p<0.05$). The ARI (Adhesive Remnant Index) results showed a higher number of fractures at the bracket/composite interface in Groups 1, 2, 3 and 5.

**Keywords:** Composite resins. Shear bond strength. Orthodontic brackets.

## INTRODUCTION

Until the 1960s, an orthodontic appliance was assembled by fabricating bands on all the teeth. This procedure was extremely work-intensive, with a long chair time, discomfort for the patient, difficult to clean, esthetically unfavorable and after the appliance was removed, spaces remaining between the teeth were observed.[2]

Replacement of the banding system by accessories bonded directly to the tooth enamel was an advancement achieved in orthodontics that benefited not only the patient, but the professional as well. This was only possible due to the classic work of Buonocore,[6] who observed that acid etching the enamel increased the adhesion of acrylic resin to the tooth surface. As from this discovery,

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various materials for attaching accessories to teeth have appeared.[10] With this development, it became quicker and easier to assemble the appliance, contributing greatly to the popularization of orthodontics.

Although it is simple, the bonding technique requires steps that must be followed in an ordered and careful manner, in order not to compromise accessory bonding to the tooth enamel.[5] The clinical procedures necessary for adequate bonding with conventional systems are prophylaxis, enamel etching, primer application, composite placement at the bracket base, and bonding itself.[3,4,5,7]

The bracket bonding technique has been modified and improved over the years. New materials and items of equipment regularly appear, with the purpose of simplifying the procedure and making it faster, however, without losing the quality necessary for attaching the accessory to the tooth, and enabling it to resist the masticatory forces as well as those of orthodontic mechanics.

In view of the wide range of bonding materials at the orthodontist's disposal, it is necessary to know their properties, in addition to testing them, to prove their efficacy. The aim of the present article was to evaluate the shear bond strength and Adhesive Remnant Index (ARI) of orthodontic brackets bonded with the composites Orthobond and Eagle Bond to surfaces etched with phosphoric acid and with a self-etching agent Transbond Plus Self Etching Primer (TPSEP).

## MATERIAL AND METHODS

In this in vitro study, 75 bovine permanent mandibular incisors were used. They were cleaned, stored in a 10% formaldehyde solution and kept in a refrigerator at an approximate temperature of 6°C.

The teeth were embedded in PVC reduction sleeves (Tigre, Joinville, Brazil) with acrylic resin (Clássico, São Paulo, Brazil), so that only their crowns were exposed. When they were embedded, the buccal surfaces of these crowns were placed perpendicular to the base of the die with the aid of a 90º set square made of glass, with the purpose of enabling correct mechanical testing. After polishing the resin, all the sets were stored in distilled water and again placed in the refrigerator.

Before bonding, the buccal surfaces of the teeth received rubber cup prophylaxis (Viking, KG Sorensen, Barueri, Brazil), with extra-fine pumice stone (S.S.White, Juiz de Fora, Brazil) and water for 15 seconds. After this they were washed with air/water spray for 15 seconds and dried with an oil- and humidity-free jet of air for the same length of time. After every five prophylaxes, the rubber cup was replaced to standardize the procedure.

After prophylaxis, the test specimens were randomly divided into five groups (n=15) and maxillary central incisor brackets (Abzil Lancer, São José do Rio Preto, Brazil) with a base area of 13.8 mm² were selected to be bonded to the specimens.

» Group 1 (control): Enamel conditioning with 37% phosphoric acid for 15 seconds, washing and drying for the same period of time, application of XT primer, bracket bonding with Transbond XT, removal of excesses using an exploratory probe (Duflex, Juiz de Fora, Brazil), light curing for 40 seconds, being 10 seconds on each surface (mesial, distal, incisal and gingival) at a distance of 1 mm from the bracket, using a XL 1500 appliance (3M, Dental Products, Monrovia, USA) with light intensity of 450 mw/cm², regularly checked with a radiometer (Demetron, Danburry, CT, USA).

» Group 2: Enamel etching with 37% phosphoric acid for 15 seconds, washing and drying for the same period of time, application of Orthoprimer (Morelli, Sorocaba, São Paulo, Brazil) on the etched surface, placement of the composite Orthobond (Morelli) at the base of the bracket, placing it in position and removing the excesses.

» Group 3: Application of TPSEP (3M Unitek,

Monrovia, USA), rubbing on the enamel for 3 seconds, light air jet to spread the material, placing the composite Orthobond (Morelli, Sorocaba, São Paulo, Brazil) at the base of the bracket, placing it in position and removing the excesses.

» Group 4: Enamel etching with 37% phosphoric acid for 15 seconds, washing and drying for the same period of time, application of Eagle Bond primer (American Orthodontic, Sheboygon, USA) on the etched surface, light curing the primer for 15 seconds, placement of the composite Eagle Bond (American Orthodontic, Sheboygon, USA) at the base of the bracket, placing it in position and removing the excesses.

» Group 5: Application of TPSEP (3M Unitek, Monrovia, USA), rubbing on the enamel for 3 seconds, light air jet to spread the material, placing the composite Eagle Bond (American Orthodontic, Sheboygon, USA) at the base of the bracket, placing it in position and removing the excesses.

After bonding the test specimens were stored in distilled water and kept in an oven at a temperature of 37°C for 24 hours.

To perform the mechanical test a device was fabricated to keep the specimen stable during the test (Fig 1). The specimens were submitted to the shear test in an Emic DL 10.000 universal test machine (São José dos Pinhais, Brazil) operating at a speed of 0.5 mm/min, by means of a chisel-shaped active tip/rod (Fig 2). The shear bond strength results were obtained in Kgf, transformed into N and divided by the bracket base area to provide results in MPa.

After performing the test, the buccal surface of each test specimen was evaluated under a stereoscope (Carl Zeiss, Göttingen, Germany) at 8X magnification in order to quantify the Adhesive Remnant Index (ARI) as recommended by Årtun and Bergland:[1] 0= no quantity of composite adhered to the enamel; 1= less than half of the composite adhered to the enamel; 2= over half of the composite adhered to the enamel; 3= all of the composite adhered to the enamel.

The shear bond strength test results were sub-


FIGURE 1 - Device fabricated to maintain the specimen stable during the test.

FIGURE 2 - Mechanical test being performed in the EMIC test machine

mitted to the analysis of variance (ANOVA) and afterwards to the Tukey test in order to compare the control with the other treatments. To evaluate the ARI scores, the Kruskal-Wallis test was used.

## RESULTS

In the comparison of the shear bond strength values (Table 1) no statistically significant differences were found among between Groups 1 (Conventional Transbond XT), 2 (Conventional Orthobond), 3 (Orthobond to enamel conditioned with Transbond Plus Self Etching Prime), and 5 (Eagle Bond to enamel conditioned with Transbond Plus Self Etching Prime). Statistical differences were found between Groups 1 and 4 (Eagle Bond conventional), which presented the lowest shear bond strength, as shown in Table 1 and Figure 3.

In the evaluation of the Adhesive Remnant Index (ARI), the scores were observed within each group, as shown in Table 2.

Between Groups 1 and 2 (p=0.178); 1 and 3 (p=0.107); 2 and 3 (p=0.467); 1 and 5 (p=0.103); 2 and 5 (p=0.121) and 3 and 5 (p=0.165) no statistically significant differences were found in the evaluation of ARI. However, statistically significant differences were observed between Groups 1 and 4 (p=0.000); 2 and 4 (p=0.000); 3 and 4 (p=0.000), and 4 and 5 (p=0.002).

TABLE 1 - Mean shear bond strength values and standard deviation.

| Groups | Mean (MPa) |
|---|---|
| 1 | 10.62 (3.64) |
| 2 | 7.28 (3.06) |
| 3 | 7.85 (2.31) |
| 4 | 6.89 (4.6) |
| 5 | 9.22 (2.38) |

TABLE 2 - Scores and mean post of the Adhesive Remnant Index (ARI) presented by the groups.

| Groups | ARI Scores | | | | Mean Post |
|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | |
| 1 | 4 | 4 | 2 | 5 | 33.43 |
| 2 | 1 | 3 | 4 | 7 | 44.70 |
| 3 | 0 | 0 | 8 | 7 | 50.97 |
| 4 | 4 | 9 | 2 | 0 | 18.93 |
| 5 | 2 | 1 | 7 | 5 | 41.97 |

0 = No quantity of adhesive adhered to the enamel.
1 = Less than half of the adhesive adhered to the enamel.
2 = Over half of the adhesive adhered to the enamel.
3= All of the adhesive adhered to the enamel.

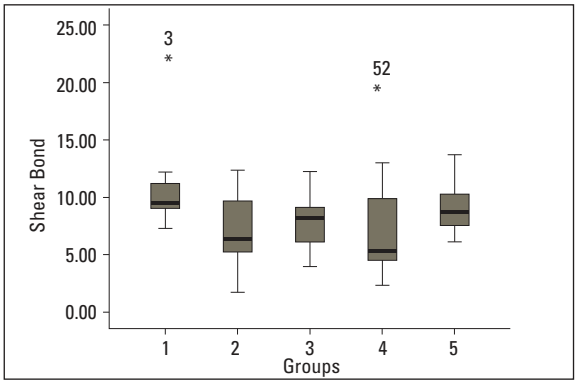


FIGURE 3 - Box Plot demonstrating the shear bond strength values among the evaluated groups.

## DISCUSSION

In an endeavor to diminish the number of procedures in the conventional bonding technique and the patient's chair time, Self-Etching Primers (SEP) have been developed. These systems are formed by a primer and acid in a single solution, capable of etching the tooth surface, promoting the action of the primer and do not require washing and drying after they have been applied.[9] Few studies in the literature have evaluated to effectiveness of these new SEPs in terms of bond strength when used with the various composites available on the market. Therefore, the purpose of the present study was to evaluate the shear bond strength and the Adhesive Remnant Index when the surface was prepared with TPSEP.

As control, bonding was performed with the use of Transbond XT, an exhaustively tested material with proven characteristics of resistance to masticatory forces.[8,11]

In addition to the control group, bonding was performed with the materials Orthobond and Eagle Bond in accordance with the manufacturers' instructions. These groups served as a standard for the comparison of the real influence of TPSEP in bonding procedures.

In the comparison of the shear bond strength values, no statistically significant differences were found among the groups in which conventional Transbond XT (1), conventional Orthobond (2), Orthobond to enamel conditioned with TPSEP (3), and Eagle Bond to enamel conditioned with TPSEP (5) were used. The application of TPSEP associated with the composites Orthobond and Eagle, facilitated bonding by eliminating steps, and did not alter bonding, but indeed improved it, as was the case in Group 5, which presented the best results when compared with Group 4, which was bonded in accordance with the manufacturer's technique.

Statistical differences were found between the Control and the group in which conventional Eagle Bond was used, with the latter showing the lowest mean shear bond strength in comparison with the other groups.

When comparing the shear bond strength means presented by the five groups with the values suggested by Reynolds and Franhofer[13] as being adequate for the majority of procedures performed in orthodontics, (between 5.9 and 7.8 MPa), one finds that the values obtained for the groups were compatible with clinical requirements. This finding is of clinical interest, since the use of TPSEP makes the bonding procedure 65% faster, according to Whyte.[12]

In the evaluation of the Adhesive Remnant Index (ARI), no statistically significant differences were found between Groups 1 and 2; 1 and 3; 1 and 5; 2 and 3; 2 and 5; and 3 and 5. Statistically significant differences were observed between Groups 1 and 4; 2 and 4; 3 and 4; and 4 and 5. These differences were a result of the lower ARI values for Group 4, in which Eagle Bond was used in accordance with the manufacturer's technique. The adhesion to the tooth provided by the association of TPSEP, favored higher means (bond strength) and consequently, protection of the enamel during bracket debonding, since the largest quantity of composite remained adhered to the tooth enamel.

## CONCLUSION

It could be concluded that TPSEP is an important aid when quicker work is required during bracket bonding with the use of composites Orthobond and Eagle Bond.

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