

# Shear bond strength of a new composite for orthodontic use under different situations

Matheus Melo Python<sup>1</sup>, Rogério Lacerda dos Santos<sup>1</sup>

<sup>1</sup>Specialist in Orthodontics, Faculdade de Odontologia, Universidade Federal de Alfenas (Unifal), Alfenas, MG, Brazil; Master and doctorate student, Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, RJ, Brazil

## Abstract

**Aim:** The aim of this study was to evaluate the shear bond strength of metallic orthodontic brackets bonded with Eagle Bond composite under different enamel surface conditions. **Methods:** Ninety bovine permanent lower incisors were divided into six groups (n = 15). In Group 1 (control) and Group 2 the brackets were bonded with XT primer/Transbond XT composite (3M Unitek) and Eagle Bond primer/Eagle Bond composite (American Orthodontic), respectively, according to the manufacturers' recommendations. In the other groups, the brackets were bonded with Eagle Bond composite as follows: Group 3 had an enamel surface treated with Transbond Plus Self-Etching Primer; Group 4, bonding without application of Eagle Bond primer; Group 5, use of homogenized Eagle Bond composite; and Group 6, Eagle Bond primer/Eagle Bond composite applied on saliva/blood-contaminated dental surface. After bonding of the brackets, all specimens were tested in shear strength in an Emic universal testing machine at a crosshead speed of 0.5 mm/min. **Results:** There were no statistically significant differences among the groups (p > 0.05). A larger number of fractures were detected at the bracket/composite interface by the analyses of the Adhesive Remnant Index scores. **Conclusions:** It may be concluded that the modifications on the enamel surface did not compromise the shear bond strength of the composite Eagle Bond.

**Keywords:** shear strength, dental bonding, orthodontic brackets.

## Introduction

Until the 1970s, orthodontic accessories were fixed by using bands in all teeth. According to Zachrison<sup>1</sup>, such a bonding procedure had several disadvantages, which included, difficult cleaning, complexity, time-consuming clinical application and loss of esthetics. As a result, the technique for directly bonding orthodontic accessories to teeth was considered an essential advance for developing, simplifying and expanding Orthodontics. This direct bonding technique was possible only after the advent of the acid etching<sup>2</sup>, which became a routine procedure for bonding fixed appliances.

The first paper known to address the direct bonding of brackets to dental surface dates back to the late 1950's<sup>3</sup>. According to Nordenvall et al.<sup>4</sup>, such a technique brought several advantages to Orthodontics, namely absence of proximal contact<sup>5</sup>, easy bonding and debonding of accessories, shorter chair-time, esthetics, improved oral hygiene and less incidence of gingival inflammation<sup>5,6</sup>.

A wide array of materials have been developed in recent years for bonding orthodontic brackets and, thus the scientific knowledge of these materials is crucial for their clinical use. These composites usually have high bond strength, hardness and dimensional stability, and they also have some disadvantages regarding viscosity, preparation time<sup>7-11</sup> and fluoride release<sup>12</sup>.

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Correspondence to:

Centro Odontomédico Dr. Altamirando da Costa Lima  
Matheus Melo Python  
Avenida Otávio Santos, 395 – sala 705 – Recreio  
CEP 45020-750 – Vitória da Conquista (BA), Brazil  
E-mail: matheuspython@bol.com.br

Eagle Bond composite (American Orthodontic, Sheboygan, WI, USA) is one of the composites currently introduced to the dental market, and little research has been done with this material. According to the manufacturer, Eagle Bond is easily applied, has good bond strength and moderate viscosity.

The actual need of testing newly introduced materials justifies the present study, whose objective was to evaluate both the shear bond strength and the Adhesive Remnant Index (ARI) of Eagle Bond composite, applied according to the manufacturer's instructions and under different experimental conditions.

## Material and methods

Ninety bovine permanent lower incisors were selected, properly cleaned, stored in 10% formaldehyde solution and kept refrigerated at 6 °C.

The teeth were embedded in PVC cylinders (Tigre, Joinville, Brazil) filled with acrylic resin (Clássico, São Paulo, Brazil), in such a way that only their crowns were left exposed. The buccal surfaces of the crowns were positioned perpendicular to the shearing die's base, using a T-square to ensure that the mechanical test could be performed correctly. After resin polymerization, the specimens were stored in distilled water and maintained in refrigeration.

Prior to the bonding procedures, the buccal surfaces of all teeth were subjected to prophylaxis with a slurry of extra-fine pumice (S.S. White, Juiz de Fora, MG, Brazil) and water in a rubber cup (Viking, KG Sorensen, Barueri, SP, Brazil) for 15 seconds. Next, the specimens were washed with an air/water spray for 15 seconds and dried with oil/moisture-free air streams for 15 minutes. The rubber cup was replaced after every five consecutive applications in order to keep the experimental pattern.

After prophylaxis, the specimens were randomly divided into six groups (n = 15), and upper central incisor brackets (Abzil Lancer, São José do Rio Preto, SP, Brazil) with a base area of 13.8 mm<sup>2</sup> were used in the bonding procedures. The six groups are divided as follows:

- Group 1 (Control): the enamel surfaces were etched with 37% phosphoric acid during 15 seconds, afterwards they were cleaned and dried in the same time. XT primer was applied and the brackets were bonded with Transbond XT (3M Unitek, Monrovia, USA) composite. Material in excess was removed with a sharp explorer (Duflex, Juiz de Fora, Brazil);
- Group 2: the enamel surfaces were etched with 37% phosphoric acid during 15 seconds, then, cleaned and dried for the same period of time; Eagle Bond primer (American Orthodontic) was applied on the etched enamel and light-cured for 15 seconds. Eagle Bond composite (American Orthodontic) was applied on the base of the brackets, which were positioned, and the material in excess was removed;
- Group 3: transbond Plus Self Etching Primer - TPSEP (3M Unitek) was applied by rubbing it onto the enamel surface during three seconds; air-thinning of the material; application of Eagle Bond

composite (American Orthodontic) on the base of the brackets, which were positioned, and the material in excess was removed;

- Group 4: the enamel surfaces were etched with 37% phosphoric acid during 15 seconds, then they were cleaned and dried for the same time; Eagle Bond composite (American Orthodontic) was applied on the base of the brackets, which were positioned, and the material in excess was removed;
- Group 5: the enamel surfaces were etched with 37% phosphoric acid during 15 seconds, then they were cleaned and dried for the same time; Eagle Bond composite (American Orthodontic, Sheboygan, USA) was homogenized at a ratio of 1 g of composite to one drop of primer and applied to the base of the brackets, which were positioned, and the material in excess was removed;
- Group 6: the enamel surfaces were etched with 37% phosphoric acid during 15 seconds, then they were cleaned and dried for the same time; Eagle Bond primer (American Orthodontic) was applied on the etched enamel and light-cured for 15 seconds; the enamel surfaces were contaminated with blood/saliva and dried; Eagle Bond composite was applied to the base of the brackets, which were positioned and the material in excess was removed.

The composition of Eagle Bond is paste composed of silica, Bis-GMA, silane, N-dimethyl benzocaine, hexafluoride phosphate; primer with Bis-GMA, silane, N-dimethyl benzocaine, hexafluoride phosphate.

The brackets were light-cured during 40 seconds (ten seconds for each face –mesial, distal, incisal and gingival) at a distance of 1 mm, a halogen light-curing device (XL 1,500; 3M Dental Products, Monrovia, USA) with light intensity of 450 mW/cm<sup>2</sup> as measured with curing radiometer (Demetron, Danbury, CT, USA). After the bonding procedures, the specimens were stored in distilled water at 37 °C for 24 hours.

A custom-made device was developed to hold the specimen completely stable during the mechanical test. The shear bond strength test was performed in a universal testing machine (Emic DL 10.000; São José dos Pinhais, PR, Brazil), at a crosshead speed of 0.5 mm/min through a chisel-shaped rod. The results were obtained in Kgf, converted into N and, then divided by the base area of the bracket so that values in MPa could be obtained.

After the mechanical test, the buccal surface of each specimen was evaluated with a stereoscopic magnifying glass (Carl Zeiss, Gottingen, Germany), at ×8 magnification in order to quantify the ARI, according to the criteria established by Artun and Bergland<sup>7</sup>, that is, zero means no adhesive left on the enamel surface; one, less than half of the adhesive left on the enamel surface; two, more than half of the adhesive left on the enamel surface; and three, all the adhesive left on the enamel surface.

Shear bond strength mean values were analyzed statistically by analysis of variance and Tukey's test, in order to compare Group 1 (Control) to the Experimental Groups. Kruskal-Wallis test was used for assessing the ARI scores.

## Results

No statistically significant differences were found between Group 1 (XT primer/Transbond XT composite – Control), Group 2 (Eagle Bond primer/Eagle Bond composite), Group 3 (Transbond Plus Self-Etching Primer + Eagle Bond composite), Group 4 (Eagle Bond composite without primer), Group 5 (Homogenized Eagle Bond composite), and Group 6 (Eagle Bond composite applied to saliva/blood-contaminated enamel). However, as can be seen in **Table 1**, Group 2 presented the highest shear bond strength numerical mean values ( $p > 0.05$ ), as can be seen in **Figure 1**. The ARI scores in each group are presented in **Table 2**.

Regarding Group 1, no statistically significant differences were found in relation to Group 2 ( $p = 0.154$ ), Group 3 ( $p = 0.321$ ), Group 4 ( $p = 0.999$ ), Group 5 ( $p = 0.130$ ), and Group 6 ( $p = 0.335$ ). The same was observed for Group 2 in relation to Groups 4 ( $p = 0.154$ ), 5 ( $p = 0.775$ ), and 6 ( $p = 0.539$ ), as well as between Groups 4 and 5 ( $p = 0.130$ ) and Groups 4 and 6 ( $p = 0.335$ ). However, statistically significant differ-

ences were observed between Groups 2 and 3 ( $p = 0.002$ ), Groups 3 and 5 ( $p = 0.006$ ), and Groups 3 and 6 ( $p = 0.008$ ).

## Discussion

Transbond XT (Group 1 – Control), which has confirmed adhesive characteristics, was used in the present study according to the manufacturer's instructions. No statistically significant differences were observed comparing the shear bond strengths of all groups, although Group 2 had the lowest values. These results indicate that Eagle Bond is appropriate for bonding orthodontic accessories to enamel surface, with shear bond strength ranging from 5 to 20 MPa, which is considered by Owens and Miller<sup>13</sup> to be sufficient to resist the orthodontic forces.

As mentioned above, no statistically significant difference ( $p > 0.05$ ) was found between Group 2 (conventional Eagle Bond) and 3 (Eagle Bond + Transbond Plus Self Etching Primer - TPSEP), which is consistent with the findings of previous studies<sup>8,14</sup> using Transbond XT under similar conditions. Similar results were also reported by Romano et al.<sup>15</sup> using Transbond XT and Z 100, and by Pithon et al.<sup>16</sup>, using Orthobond composite. This finding is of clinical relevance, since TPSEP has been shown to make the bonding procedure 65% faster, according to Whyte<sup>17</sup>.

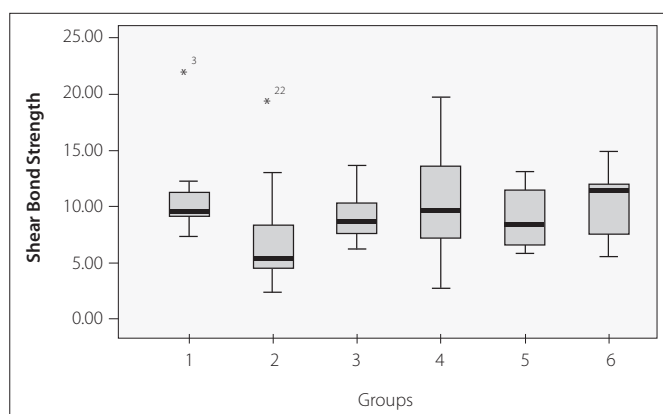
Aiming at simplifying the technique proposed by the manufacturer, Eagle Bond was used for bracket bonding without the priming step (Group 4). The mean shear bond strength was higher than that obtained for Group 2 (Eagle Bond with primer), though without statistical significance. This result is of great importance since a bonding step can be eliminated, shortening the clinical chairtime, and may be due to the lower resistance of the resin without load that was applied in Group 2. However, it is important to have in mind that, although the elimination of this step reduces the clinical chairtime, the priming procedure protects the etched enamel that was not covered by the bracket after bonding.

Among the innumerable questions raised by other studies, regarding composites used for bonding orthodontic accessories, the behavior of these materials when previously homogenized should also be known. Composite homogenization is justifiable for achieving a suitable distribution of the components, which would allow an improved flow during direct bonding of orthodontic brackets<sup>18,19</sup>. The bonding ability of homogenized Eagle Bond (Group 5) was compared to the bonding ability of the conventional composite (Group 2). No significant difference was found between the groups, suggesting that homogenized Eagle Bond would be a viable alternative when an improved flow is desirable. Similar results were also found by Patel et al.<sup>18</sup>, who tested the homogenization of the Superbond composite.

Contamination of dental surface, with either blood or saliva during the bonding procedures, happens all the time. The interference of contamination after drying the contaminated area (Group 6) was tested. No significant difference was found between the groups, which is also consistent with the findings of Pithon et al.<sup>20</sup>,

**Table 1.** Mean shear bond strength values and standard deviation

Groups	Mean values (MPa)
1	10.62 (3.64)
2	6.89 (4.62)
3	9.22 (2.38)
4	10.33 (4.69)
5	9.03 (2.58)
6	10.25 (2.98)



**Figure 1.** Box plot with shear bond strength mean values for all groups evaluated.

**Table 2.** Adhesive Remnant Index (ARI) scores and average rank for each group

Groups	ARI scores				Average rank
	0	1	2	3	
1	4	4	2	5	49.93
2	4	9	2	0	35.93
3	2	1	7	5	61.77
4	4	4	2	5	49.93
5	7	4	3	1	34.87
6	3	9	2	1	40.57

0: no adhesive left on the enamel surface; 1: less than half of the adhesive left on the enamel surface; 2: more than half of the adhesive left on the enamel surface; 3: all the adhesive left on the enamel surface.

who used similar methodology with another composite. Therefore, it was demonstrated that the whole clinical sequence did not need to be repeated, provided that the contaminated area was dried before bonding the brackets. Once the enamel surface is contaminated with blood and saliva during the bonding procedure, it is necessary to dry the area to be bonded with Eagle Bond in order to obtain enough bond strength.

Regarding the ARI, no statistically significant differences were found between the groups, except between Groups 2 and 3, Groups 3 and 5, and Groups 3 and 6. Such differences were due to the lower ARI scores observed in Groups 2, 5 and 6, compared to the higher ARI scores observed in Group 3, in which Transbond Plus Self Etching Primer was used. The good adhesiveness to the teeth, promoted by associating Eagle Bond with TPSEP, favored the achievement of higher shear bond strength mean values and, hence enamel protection during bracket debonding, that is, a greater amount of the adhesive material was left on the enamel surface.

In Groups 2 and 5, however, the majority of fractures occurred at the enamel/composite interface following the debonding process, with ARI scores being predominantly zero or one, that is, no or lesser amount of composite adhered to enamel. Such a result may be explained by the improved flow, provided by either primer application before bonding the brackets (Group 2), or composite homogenization (Group 5). These results are favorable as far as the maintenance of enamel integrity is concerned, since enamel micro or macrofragments can be removed together with bracket and composite during debonding. The values obtained in Groups 2 and 5 are corroborated by most studies in the literature<sup>21,22</sup>.

Based on the results of the present study, the following conclusions may be drawn: conventional Transbond XT and Eagle Bond systems showed good results in the shear bond strength testing, when bonded to enamel surface etched with 37% phosphoric acid; Eagle Bond composite presented good bond strength to enamel, treated with Transbond Plus Self Etching Primer; the use of Eagle Bond primer was found to be facultative, that is, it was not necessary for achieving full adhesion; and homogenization of Eagle Bond composite did not reduce the shear bond strength values, being an alternative if improved flow is desirable.

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