Original Article

Effect of a Self-etching Primer on Shear Bond Strength of Adhesive Precoated Brackets In Vivo

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Abstract: The aim of this study was to evaluate the influence of a self-etching primer (SEP) (Transbond Plus SEP, 3M Unitek, Monrovia, Calif) on shear bond strength of adhesive uncoated and precoated Victory brackets (3M Unitek). The sample group consisted of 23 patients, with four premolars each, equally divided in four different groups. Brackets were bonded in vivo by the same operator using a split-mouth random technique: group 1, 37% phosphoric acid + primer + composite + conventional Victory bracket; group 2, 37% phosphoric acid + primer + precoated Victory bracket; group 3, SEP + composite + conventional bracket; group 4, SEP + precoated bracket. After 30 days, premolars were extracted for orthodontic reasons and a Universal Instron 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 two-way analysis of variance. Mean results and standard deviation for the groups were: group 1 = 11.60 ± 2.65 Mpa, group 2 = 9.79 ± 2.71 Mpa, group 3 = 10.75 ± 2.67 Mpa, and group 4 = 10.31± 2.70 Mpa. No difference was observed between the conventional etching and primer or SEP ($P = .948$). However, significant differences in bond strength were present between the uncoated and precoated brackets ($P = .032$). Considering the values required to withstand normal orthodontic forces (8–9 Mpa), it could be concluded that the SEP combined with adhesive precoated brackets showed adequate shear bond strength and may be suitable for clinical use. (*Angle Orthod* 2006;76:127–131.)

Key Words: Adhesive Precoated Brackets; Phosphoric acid etching; Self-etching primer; Shear bond strength

INTRODUCTION

The enamel-etching technique presented by Buonocore[1] is commonly used with composite resin when attaching brackets to the enamel surface. In the past few years, there has been a major research drive to increase bond strength between dental materials and dental hard tissues, although most of the adhesive systems have provided clinically acceptable bond strengths. Despite the fact that the acid-etching technique is a useful procedure in orthodontics, there is a need to improve the bonding procedure to maintain clinically useful bond strengths while minimizing the amount of enamel loss and to simplify the technique, reducing the number of steps.[2,3]

In restorative dentistry, newly bonding systems were developed to combine conditioning and priming agents into a single acidic primer for simultaneous use on enamel and dentin, eliminating the separate steps of etching, rinsing, and drying.[4] The use of a self-etching primer (SEP) would have the advantage of being a faster and simplified application technique by allowing adequate etching and priming of enamel and dentin in only one step.[2,5] In addition to saving time, fewer steps in the bonding process might translate into fewer procedural errors, minimizing technique sensitivity.

Recently, a new SEP, Transbond Plus SEP (3M Unitek, Monrovia, Calif), was developed especially for orthodontic bonding. It includes methacrylate phosphoric acid esters, which will both etch and prime the enamel surface before bonding. The manufacturers also claim that the enamel dissolution can be reduced without sacrificing adequate bond strength.

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Accepted: February 2005. Submitted: December 2004.

In another attempt to save chair-time and perform simpler bonding procedures, metal brackets have been precoated with composite resin. Precoating the brackets requires modifications in the composition of the conventional adhesive used on uncoated brackets to increase the viscosity.[6] Cooper et al[7] listed the following advantages of Adhesive Precoated Brackets (APC, 3M Unitek) over conventional light-cured systems: (1) consistent quality and quantity of adhesive, (2) easier cleanup after bonding, (3) improved asepsis, (4) reduced waste during bonding, and (5) better inventory control. More recently, additional modifications were done in the composition of the adhesive used with precoated brackets, and APC II (3M Unitek) was introduced.

The purpose of this study was to investigate the relationship between the shear bond strength of orthodontic brackets bonded to enamel, with a conventional etch/priming technique or a SEP system using either adhesive uncoated or precoated brackets. The hypothesis to be tested is whether there is a difference in the mean shear bond strength between the use of a conventional multistep or SEP and when they were used with either adhesive precoated or uncoated brackets.

MATERIALS AND METHODS

A total of 23 patients taken off the waiting list for treatment at the Department of Orthodontics, School of Dentistry, State University of Rio de Janeiro, participated in this study. They were eligible for the study if they required extraction of four premolars for orthodontic reasons. Sex, age, race, and malocclusion differences were ignored, and ethical approval was obtained from the local research committee.

Before extraction, standard edgewise twin brackets (Victory Series, 3M Unitek) were bonded to the buccal surfaces of the teeth. These are available in conventional uncoated and adhesive precoated versions. The average bracket base surface area was determined to be 10.61 mm^2. A total of 92 brackets were bonded.

The teeth were divided into four equal groups, with equal numbers of first, second, upper, and lower premolars in each group to prevent bias caused by the possible differences in bond strength among tooth types.[8] All materials were mixed and applied according to the manufacturers' instructions by a single operator following one of four protocols for each tooth:

- Group 1 (PAXT); The teeth were etched with 37% phosphoric acid. Conventional uncoated Victory brackets were bonded with Transbond XT Primer and Adhesive Paste (3M Unitek). This group served as the control.
- Group 2 (PAAPC); The teeth were etched with 37% phosphoric acid. Adhesive Precoated Victory brackets (APC II) were bonded using Transbond XT Primer.
- Group 3 (SEPXT); Transbond Plus SEP (3M Unitek) was applied on enamel surface. Conventional uncoated Victory brackets were bonded using Transbond XT Adhesive Paste.
- Group 4 (SEPAPC)—Transbond Plus SEP was applied on enamel surface, followed by APC II placement.

Firm pressure was used to completely seat the bracket on the tooth, after which excess bonding resin was removed with a small scaler. According to the manufacturer's instructions, each bracket was light polymerized with Ortholux XT visible light–curing unit (3M Unitek) for 20 seconds. The light was applied for 10 seconds at both the mesial and distal aspect of the bracket. A minimum irradiance of 400 mW/cm^2 was verified with a curing radiometer (Model 100, Demetron Research, Danbury, Conn) after each specimen was polymerized.

The bonded brackets were maintained in the mouth for at least 30 days before extraction. The teeth were extracted using only surgical elevators to avoid contact with the brackets. The extracted teeth were washed and stored in a solution of 0.1% (wt/vol) thymol.

The specimens were mounted in plastic rings with acrylic. A mounting jig was used to align the bracket base to be perpendicular with the bottom of the mold and parallel to the force during the shear strength test. An Instron Universal Testing Machine (Instron Ltd, High Wycombe, UK) was used to apply an occlusogingival load to the bracket, which produced a shear force at the tooth-bracket interface with a crosshead speed of 0.5 mm/min. 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 megapascals (Mpa).

After debonding, the teeth and brackets were examined under a 10× magnification to evaluate the amount of resin remaining on the tooth. The adhesive remnant index (ARI)[9] 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, no adhesive remained on the tooth; 1, less than half of the enamel bonding site was covered with adhesive; 2, more than half of the enamel bonding site was covered with adhesive; and 3, the enamel bonding site was covered entirely with adhesive.

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 Kolmogorov-Smirnov method. Two-way analysis of variance

TABLE 1. Results of Two-way Analysis of Variance Comparing Shear Bond Strengths (MPa) of Experimental Groups

Group	n	Mean*	SD	Range
1. PAXT	23	11.35	2.36	6.51–14.75
2. PAAPC	23	9.77	2.49	4.62–13.26
3. SEPXT	23	10.89	2.60	3.32–15.87
4. SEPAPC	23	10.16	2.75	4.98–14.24

* Interaction not significant ($P = .431$). Main effect of enamel conditioning was not significant ($P = .948$). Main effect of bracket/adhesive was significant ($P = .032$).

(ANOVA) was used to test for differences between groups and any statistical interaction between the enamel conditioning and the type of bracket/adhesive used. Weibull analysis, which relates the probability of bracket failure to the applied load, was also carried out. 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, Calif) at the 5% level of significance.

RESULTS

The descriptive statistics and results of two-way ANOVA comparing the shear strength of orthodontic brackets bonded to teeth with a conventional etching and primer or a SEP system, with precoated or uncoated brackets, are shown in Table 1. The ANOVA did not detect any significant interaction between enamel conditioning and type of bracket/adhesive ($P = .431$). The main effect of enamel conditioning and bracket/adhesive type was then tested. There was no evidence to suggest that a difference in shear bond strength existed whether a conventional etching and primer or SEP was used ($P = .948$). However, a significant difference in bond strength was present between the uncoated and precoated brackets ($P = .032$). The control group 1 (PAXT) had the highest mean debond value at 11.35 Mpa, whereas group 2 (PAAPC) had the lowest value at 9.77 Mpa.

Table 2 shows the Weibull analysis of the test groups. Weibull analysis was undertaken to examine the probability of failure, and the resulting curves are shown in Figure 1. The curves consist of the cumulative probability of bond failure plotted against the applied load.

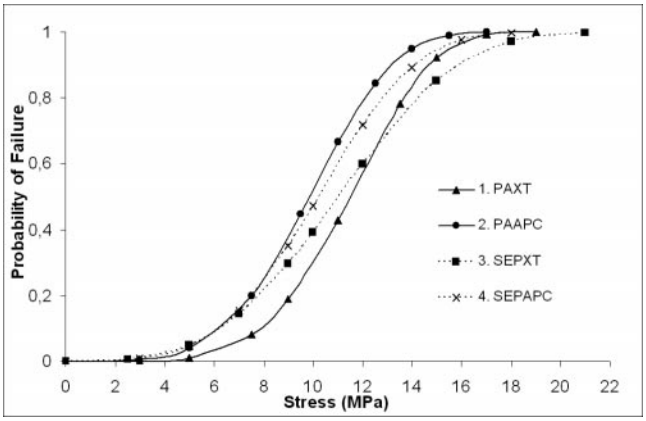

FIGURE 1. Weibull distribution plots for test groups.

TABLE 3. Frequency Distribution and Results of Chi-square Analysis of the Adhesive Remnant Index (ARI) of Experimental Groups

		ARI scores[ab]			
Group	n	0	1	2	3
1. PAXT	23	10	4	1	8
2. PAAPC	23	13	4	3	3
3. SEPXT	23	4	3	5	11
4. SEPAPC	23	7	5	4	7

[a] 0 indicates 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.

[b] $\chi^2 = 80.30$; $P = .111$.

The ARI scores for the four groups tested are listed in Table 3. The results of chi-square comparisons for the ARI indicated that there were no significant differences between the groups ($P = .111$).

DISCUSSION

The hypothesis tested was accepted partially. The results indicated that precoating brackets significantly affects the shear bond strength of orthodontic brackets when either a conventional etching and primer or a SEP system is used. The precoated adhesive contains different percentages of the same components as the original Transbond XT adhesive used with the un-

TABLE 2. Weibull Parameters for Test Groups

Group	Weibull Modulus	Characteristic Bond Strength (Mpa)	Shear Stress at 10% Probability of Failure (Mpa)	Shear Stress at 90% Probability of Failure (Mpa)
1. PAXT	4.90	12.39	7.83	14.69
2. PAAPC	4.15	10.76	6.26	13.19
3. SEPXT	3.31	12.35	6.26	15.89
4. SEPAPC	3.73	11.28	6.18	14.11

coated brackets. Although precoated brackets will simplify the clinical procedure, the current investigation indicates that the precoated adhesive composition modifications produced a decrease in shear bond strength. These results are in agreement with previous studies.[10–12]

The results of this study did not detect significant differences in bond strength measurements between the SEP and the conventional multistep system. Although there is not a formally accepted minimum clinical bond strength, the bond strength required to withstand normal orthodontic forces is believed to be between 8 and 9 Mpa.[13] In this study, bracket failure occurred between 9.77 and 11.35 Mpa. These results in agreement with other studies suggest that adequate bond strengths can be achieved with this new system when bonding is carried out on a dry enamel surface, even if APCs are used.[14–16]

The evaluation of the ARI scores indicated no significant difference in bond-failure site among the four groups. Previous investigations have shown conflicting results regarding the amount of residual adhesive on teeth with SEP. Some investigations reported more residual adhesive with SEP than with conventional phosphoric acid etching, whereas others found significantly less.[2,17,18]

Traditionally, in vitro data have been extrapolated to in vivo situations, although bond strength values might not be the best indicators of the performance of a bonding system. The Weibull analysis has been recommended for the study of bond strengths to give the clinician more information relative to the clinical performance of the product tested.[19,20] The Weibull analysis allows one to calculate the probability of bond failure under loads encountered in the oral environment. In our Weibull plots, groups 2, 3, and 4 are very similar initially whereas group 1 is significantly shifted to the right, indicating a lower probability of failure at low levels of stress.

Despite all advances, bond strength tests have shown wide variation.[21] When comparing debonding forces measured in vivo and in vitro, Pickett et al[22] found that the bond strengths in vivo were significantly lower than those measured in vitro. Possible reasons suggested could be the length of time the appliance was in the oral environment, exposing the bonded brackets to acid, saliva, and variable patient abuse and masticatory forces, all of which may have contributed to the decreased bond strength.

The findings shown in this study provide a more accurate account of in vivo bond strength when compared with other investigations that rely on in vitro results to assess bond strengths required for clinical success. This study design is considered to be of greater value in determining bond strength values after a determined period of time in the oral environment. In addition, clinical bond-failure investigations are needed to validate the performance of SEPs and APCs in vivo.

CONCLUSIONS

- Under the conditions of this investigation, the results suggest no difference in bond strength whether a conventional etching and primer or SEP is used.
- Significant differences in bond strength were present between adhesive uncoated and precoated brackets.
- The SEP combined with APCs showed adequate shear bond strength.

ACKNOWLEDGMENTS

The authors express their gratitude to 3M Unitek for supplying the brackets and adhesives for this study and to Research Foundation of Rio de Janeiro State (FAPERJ) for the financial support.

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