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Shear Bond Strength of Precoated and Uncoated Brackets Using a Self-etching Primer

An In Vitro Study

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ABSTRACT

Objective: To test the hypothesis that there are no significant differences in the shear bond strength or the adhesive remaining on the tooth after debonding between precoated and uncoated brackets using a self-etching primer.

Materials and Methods: APC Plus precoated brackets and uncoated brackets were bonded with Transbond XT adhesive using the self-etching primer Transbond Plus Self-Etching Primer (TPSEP). The brackets were bonded to extracted human premolars and categorized into two groups: (1) TPSEP/Transbond XT and (2) TPSEP/APC Plus. Shear bond strength was measured with a universal testing machine. The adhesive remnant on each tooth after debonding was quantified with image analysis equipment. Scanning electron microscope (SEM) observations of enamel surfaces treated with TPSEP were also carried out.

Results: No significant differences were observed in the shear bond strengths for the two groups evaluated ($P < .05$). TPSEP/APC Plus left significantly less adhesive on the tooth after debonding than did TPSEP/Transbond XT ($P < .05$). It was observed that SEM left a porous and potentially retentive surface.

Conclusions: There was no significant difference in the bond strength of the two systems tested, but there was a significant difference in the percentage of area of adhesive remaining on the tooth.

KEY WORDS: Precoated brackets, Self-etching primers, Shear bond strength.

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The established procedure for bonding brackets to enamel with composite resin requires a series of preparatory steps. First, the surface of the enamel is polished with a glycerin-free polishing paste before being etched with 37% phosphoric acid for 15–30 seconds. Then, the surface of the enamel is rinsed with water and dried until the surface of the enamel appears chalky. A primer is applied to the enamel, and composite resin is applied to the bracket base. Finally, the bracket is positioned on the tooth and cured.

One of the main objectives of research into bonding procedures is to seek ways of reducing chair-side time. To do this, we made an evaluation of these procedures introducing alternative products. The use of polishing pastes to clean the enamel surface before acid etching does not influence bond strength.¹

Research has been carried out into the possible nonuse of primers, but there appears to be some contradiction in the existing literature.² As an alternative to the traditional acid-etch technique, the use of nonrinse conditioners has been introduced. In a previous study, we observed that one of these products provided a bond strength that could be compared with the strength obtained when using phosphoric acid.³

Recently, the use of self-etching primers has been proposed as a way of providing etching and priming simultaneously. In a previous in vitro study, it was observed that there were no significant differences in bond strength between brackets bonded with conventional techniques and those bonded with self-etching primers.⁴⁻⁷

In a recent in vivo study, it was observed that the use of self-etching primers significantly reduced bracket bonding time in comparison with traditional bonding techniques without generating significant differences between the overall bond failure rates of the two bonding systems over a period of 6–12 months.⁸

Precoated brackets (APC, 3M Unitek Dental Products, Monrovia, CA) were introduced in 1992.⁹ They provide a more uniform adhesive thickness and a reduction in the number of bonding procedures.¹⁰ The properties of precoated brackets have improved. The recent introduction of the APC Plus system (3M Unitek Dental Products) has provided greater tolerance to humidity than have its predecessors, and the adhesive also releases fluoride.¹¹ The use of self-etching primers together with precoated brackets might provide an important saving of chair-side time by reducing the number of intermediate steps in bracket bonding procedures.

The aim of this study was to compare the shear bond strength and adhesive remnant on the tooth after debonding for APC Plus precoated brackets and uncoated brackets bonded with Transbond XT adhesive resin (3M Unitek Dental Products) using the self-etching primer Transbond Plus Self-Etching Primer (TPSEP) (3M Unitek Dental Products). Scanning electron microscope (SEM) observations of enamel surfaces treated with TPSEP were also carried out.

Teeth

Forty human upper premolars free from caries and fillings were used. These had been extracted for reasons unrelated to the objectives of this study and with the informed consent of the patients. The Murcia University Bio-ethical Commission approved the project.

The teeth were washed in water to remove any traces of blood and then placed in a 0.1% Thymol solution. Afterwards they were stored in distilled water that was changed daily. No tooth was stored for more than 1 month after extraction. With their roots set in stone, the premolars were set in a 4-cm-long copper cylinder with an internal diameter of 3 cm. Four premolars were used for SEM observations.

Brackets

A total of 25 uncoated and 15 precoated (APC Plus) upper premolar Victory Series metal brackets (3M Unitek Dental Products) were used. The base area of each bracket was calculated (mean = 9.79 mm²) by using image analysis equipment and MIP 4 software (Microm Image Processing Software, Digital Image Systems, Barcelona, Spain) under 400x magnification.

Bonding Procedure

The 40 upper premolars were categorized into two groups, and brackets were bonded onto the buccal surfaces according to the manufacturer's instructions. The buccal surfaces of both groups were polished with a rubber cup and polishing paste (Détartine, Septodont, Saint-Maur, France).

Group 1 (n = 25) consisted of TPSEP/Transbond XT. The enamel was treated with TPSEP. Transbond XT paste was applied to the base of each bracket and then pressed firmly onto the enamel surface. Excess adhesive was removed from around each bracket base. The adhesive was light cured with an Ortholux XT lamp (3M Unitek Dental Products) on each interproximal side for 10 seconds.

Group 2 (n = 15) consisted of TPSEP/APC Plus. The enamel was treated with TPSEP as in group 1. The precoated bracket was placed onto the tooth, pressing firmly. Excess adhesive was removed from around each bracket base. The adhesive was light cured as in group 1.

Storage of Test Specimens

The specimens were stored in distilled water at 37°C for 24 hours.¹²

Shear Bond Strength Testing

Shear bond strength was measured with a universal testing machine (Autograph AGS-1KND, Shimadzu, Japan) with a 1-kN-load cell connected to a metal rod with one end angled at 30°. The cross-head speed was 1 mm/min.¹² A force parallel to the tooth surface was applied to the bracket in an occlusoapical direction. The force required to debond each bracket was registered in newtons (N) and converted into megapascals (MPa = N/mm²).

Adhesive Remnant

The percentage of the bracket base surface covered by adhesive was determined with image analysis equipment (Sony dxc 151-ap video camera connected to an Olympus SZ11 microscope) (Sony, Barcelona, Spain) and MIP 4 software. The percentage of the area still occupied by remaining adhesive after debonding was obtained by subtracting the area of adhesive covering the bracket base from 100%.

The null hypothesis is that there are no significant differences in the adhesive remaining on the tooth after debonding between the groups evaluated.

Statistical Analysis


The Kolmogorov-Smirnov normality test and the Levene variance homogeneity test were applied to the bond strength data. The data showed normal distribution, and there was homogeneity of variances between the groups. They were analyzed by using the Student's *t*-test for two independent samples ($P < .05$).



The Kolmogorov-Smirnov normality test and the Levene variance homogeneity test were applied to the data for percentage of area of adhesive remaining on the tooth surface. Because the data did not show a normal distribution, a significant difference was evaluated ($P < .05$) by using the Mann-Whitney *U*-test for two independent samples ($P < .05$).

SEM Observations

Four premolars were used. The enamel was polished with a rubber cup and polishing paste, treated with TPSEP, and rinsed with acetone for 10 seconds to remove the self-etching primer.¹³ All specimens were cleaned in distilled water with ultrasonic agitation for 30 minutes and gently air dried. They were affixed to SEM stubs, coated with gold, and examined on a Jeol 6100 SEM (Tokyo, Japan) operating at 15 kV.

RESULTS [Return to TOC](#)

Bond strength values appear in [Table 1](#) . The Student's *t*-test for two independent samples did not detect significant differences between the groups evaluated ($P = .12$).

The percentage of area of adhesive remaining on the tooth showed significant differences when using the Mann-Whitney *U*-test ($P = .01$) ([Table 2](#) ). SEM observations of enamel surfaces treated with TPSEP showed a porous and potentially retentive surface ([Figure 1](#) ).

DISCUSSION [Return to TOC](#)

To our knowledge, no studies comparing the bond strength of APC Plus and Transbond XT and using TPSEP as a conditioner have been carried out.

The bond strength values achieved by the two groups were higher than those minimum values put forward by Reynolds¹⁴ as sufficient for clinically effective bonding. No significant differences were detected between the bond strengths provided by TPSEP/ Transbond XT and TPSEP/APC Plus.

Regarding the percentage of area of adhesive remaining on tooth, TPSEP/APC Plus left significantly less adhesive than did TPSEP/Transbond XT. This implies a reduction in chair-side time spent on adhesive removal after debonding. APC Plus system needs no application because each bracket is coated with the adhesive by the manufacturer, so there is less opportunity for bracket contamination during the bonding procedure; therefore, the adhesion between the adhesive and the bracket is more effective than in the conventional procedure in

which the clinician has to apply the adhesive onto the bracket base.

SEM observations of the enamel treated with TPSEP showed a porous and potentially retentive surface. Some studies show that, with unground enamel, the etching pattern provided by self-etching primers is comparable with the pattern produced by phosphoric acid.[3,15](#)

According to our results, the use of TPSEP with APC Plus reduces chair-side time without compromising bond strength. Furthermore, some characteristics of APC Plus could prove highly favorable for clinical use. This new system contains hydrophilic monomers that improve tolerance to humidity in comparison with Transbond XT or other systems that contain mainly BisGMA or other similar hydrophobic monomers.[11](#) In addition, the release of fluoride aimed at preventing decalcification of the enamel adjacent to the brackets is advantageous. In vitro bonding tests are highly important for initial evaluations of adhesive systems. However, in vivo research must be carried out to confirm in vitro results.

CONCLUSIONS [Return to TOC](#)

- a. The portion of the hypothesis that states there are no significant differences in the shear bond strength between precoated brackets and uncoated brackets bonded with an adhesive resin using a self-etching primer is accepted.
- b. The portion of the hypothesis that states there are no significant differences in the percentage of area of adhesive remaining on the tooth between precoated brackets and uncoated brackets bonded with an adhesive resin and a self-etching primer is rejected.

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TABLES [Return to TOC](#)

Table 1. Shear Bond Strength (MPa)*

Group ^a	n	Mean	Median	Range	Standard Deviation	95% Confidence Interval
TPSEP/Transbond XT	25	12.20	11.34	17.00	4.27	10.43, 13.95
TPSEP/APC Plus	15	14.28	14.00	10.6	3.41	12.39, 16.17

^a TPSEP indicates Transbond Plus Self-Etching Primer.

* The Students *t*-test for two independent samples did not detect significant differences between the groups ($P > .05$).

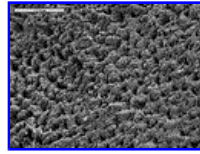
Table 2. Percentage of Tooth Area Occupied by Adhesive*

Group ^a	n	Mean	Median	Range	Standard Deviation	95% Confidence Interval
TPSEP/Transbond XT	25	39.80	25.89	79.00	25.00	29.48, 50.19
TPSEP/APC Plus	15	18.86	17.88	31.00	9.35	13.68, 24.04

^a TPSEP indicates Transbond Plus Self-Etching Primer.

* The Mann-Whitney *U*-test detected significant differences ($P < .05$).

FIGURES [Return to TOC](#)



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Figure 1. Enamel treated with TPSEP

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