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The Angle Orthodontist: **Vol. 75, No. 2, pp. 243–246.**

Effects of Using a New Protective Sealant on the Bond Strength of Orthodontic Brackets

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ABSTRACT

This study determines the effect of applying a new protective sealant to the enamel surface on the shear bond strengths of orthodontic brackets. Sixty teeth were randomly divided into three groups. In group 1 (control), the brackets were bonded to the etched teeth using the regular sealant. In group 2, the sealant was replaced with Pro Seal and light cured as recommended by the manufacturer; the brackets were then placed, and the adhesive was light cured. In group 3, Pro Seal was applied, the bracket with the adhesive was placed on the tooth, and both Pro Seal and the adhesive were cured simultaneously. The purpose of this modification was to reduce one of the steps during the bonding procedure. A shear force was applied at the bracket-tooth interface using a Zwick Universal Test Machine. The results of the analysis of variance (F-ratio = 1.35) indicated that the shear bond strengths of the three groups were not significantly different ($P = .267$) from each other. The mean shear bond strength of the control group was 4.9 ± 2.1 MPa. The mean shear bond strength for teeth coated with Pro Seal and light cured followed by application and light curing of the adhesive was 4.8 ± 2.3 MPa, and the mean for the teeth coated with Pro Seal and then bracket placed followed by simultaneous light curing of the sealant and the adhesive was 4.0 ± 1.5 MPa.

KEY WORDS: Sealant, Metal brackets, Shear bond strength.

Accepted: November 2003. Submitted: October 2003

INTRODUCTION Return to TOC

A number of strategies are suggested for caries prevention, particularly with patients who will be undergoing orthodontic treatment, including caries risk assessment. This is best performed before the treatment is initiated through the evaluation of a number of factors, which include clinical evidence of plaque control, ie, oral hygiene, use of fluoride, tooth anomalies, dietary habits, salivary flow, medical history, and social history. The introduction of orthodontic appliances in the absence of good oral hygiene will increase the potential for decalcification and gingival inflammation. Therefore, management of the caries challenge should include both prevention through proper oral hygiene and providing a balance between demineralization and remineralization of the enamel surface through the use of fluorides.[1]

Fluorides act by inhibiting demineralization and stimulate remineralization and can be applied in the form of toothpastes, mouth rinses, gels, solutions, and varnishes. Fluoride application prevents the onset and delays the progression of the caries process.[1]

The detection of dental caries should be done as early as possible through clinical and radiographic examinations. Caries progression varies on different surfaces, eg, on smooth surface areas it proceed slowly; therefore, restorative treatment can be postponed through preventive methods, including improved oral hygiene, application of fluoride, and modifications of the diet. Smooth surface lesions and white spots can be detected easily by observation and are the most likely to be arrested by preventive treatment, particularly the shiny white or brown lesions and the hard cavitated lesions that are not covered by plaque.[1]

Another important caries preventive approach is through the use of sealants, which are especially effective on recently erupted teeth and in high caries risk patients.[1] Visible light–curing sealants were developed for the prevention of caries on smooth surfaces as well as pits and fissures. The advantages of sealants include the absence of the need for irreversible tooth preparation and the prevention of the development of new carious lesions, and active lesions covered by the sealant are often arrested. The main component of sealants is dimethacrylate monomers, but these may also contain fluorides such as polymethylmethacrylate-co-methacryloyl fluoride and sodium fluoride.[1] Fluoride containing sealants also act as a fluoride reservoir through the long-term release of fluoride into the adjacent oral environment.[1,2] In an in vivo study, Wenderoth et al[3] examined the effect of placing an experimental fluoride-releasing sealant adjacent to bonded brackets in 20 patients. They evaluated various parameters including white spot formation, gingival irritation, and plaque accumulation. They found that after 5–18 months, there were no significant differences between the control teeth and those on which the sealant was applied.

Pro Seal (Reliance Orthodontic Products, Itasca, Ill) is a newly introduced fluoride-releasing light-cure, fluorescing, filled-enamel sealant. According to the manufacturer, when the highly filled Pro Seal is applied to the labial surface of the tooth, it will withstand toothbrush abrasion and the effects of oral fluids.[4] The sealant will offer maximum protection against decalcification and white spot formation. The sealant can be used with light-cure, chemical-cure, or dual-cure paste systems. It contains a fluorescing agent that enables the clinician to check for the proper application and coverage of the enamel surface. Pro Seal achieves 100% polymerization without incorporating a residual oxygen-inhibited layer. This in turn creates a smooth hard coating that prevents leakage, protects the enamel, and makes it easier to remove any excess adhesive paste during and after bonding[4] (P. Gange, personal communication).

It has also been estimated that the thickness of the Pro Seal coating on the enamel surface is approximately 30 μm and that the abrasion of the sealant under typical oral conditions is about five μm/y. As a result, the manufacturer suggests that the layer of Pro Seal coated on the tooth could last for six years[4] (P. Gange, personal communication).

This study determines the effect of applying the new protective sealant to the enamel surface on the shear bond strengths of orthodontic brackets within the first half hour after bonding. This is the time span during which the initial archwires are usually ligated.

MATERIALS AND METHODS Return to TOC

Teeth

Sixty freshly extracted human molars were collected and stored in a solution of 0.1% (wt/vol) thymol. The inclusion criteria for tooth selection included intact buccal enamel, no previous pretreatment with chemical agents such as hydrogen peroxide, no cracks due to the pressure of the extraction forceps, and no caries. The teeth were cleansed and then polished with a pumice slurry and rubber prophylactic cups for 10 seconds. All teeth were thoroughly washed and dried.

Brackets used

Sixty metal brackets precoated with the APC II adhesive (3M Unitek, Monrovia, Calif) were used. The adhesive contains 14% bis-GMA, 9% bis-EMA, and 77% fillers (silane-treated quartz and submicron silica). All brackets used were identical, ie, right maxillary central incisors of the Victory Series. The relatively flat surface of the central incisor bracket provides a good fit to the flat part of the buccal surface of the molar. The average surface area for the bracket base was 11.8 mm^2. The surface area was the average obtained by measuring five brackets.

Bonding procedure

The 60 teeth were randomly divided into three groups: group 1 (control), the brackets were bonded to the teeth using the regular sealant supplied with the adhesive system; group 2, the sealant was replaced with Pro Seal and light cured as recommended by the manufacturer, then, the bracket with the adhesive was placed and light cured; and group 3, Pro Seal was applied, and the bracket with the adhesive was placed on the tooth. Both Pro Seal and the adhesive were then cured simultaneously. The purpose of this modification was to reduce the bonding time by eliminating one of the steps recommended by the manufacturer.

Group 1—control

A 37% phosphoric acid gel was applied to the enamel surface of each tooth for 30 seconds. The teeth were then rinsed with a water spray for 20 seconds and dried with an oil-free air source for 20 seconds until the enamel surface of the etched teeth appeared to be chalky white. The regular sealant for APC II was applied, and the precoated bracket was properly positioned on the tooth. Each bracket was subjected to 300 g of force using a force gauge (Correx Co, Bern, Switzerland) for 10 seconds, and any excess bonding resin was removed using a small scaler. The bracket was then light cured for 20 seconds with an Ortholux XT Visible Light Curing Unit (3M Dental Products, St Paul, Minn). Ortholux has a high-intensity light with an output of at least 600 mW/cm^2.

Group 2—Pro Seal and adhesive cured separately

Twenty teeth were etched, washed, and dried as in group 1. Pro Seal was then applied to the enamel surface using a brush to ensure the application of a uniform layer. The Pro Seal was light cured for 10 seconds, and the precoated bracket was placed on the tooth and light cured for 20 seconds as in group 1.

Group 3—Pro Seal and adhesive cured simultaneously

Twenty teeth were treated as in group 2, but after the layer of Pro Seal was applied, the precoated bracket was immediately placed on the tooth, and both the Pro Seal and the adhesive were light cured simultaneously for 20 seconds.

All teeth were embedded in self-cure acrylic placed in phenolic rings (Buehler Ltd, Lake Bluff, Ill). A mounting jig was used to align the facial surfaces of the teeth perpendicular to the bottom of the mold so that the labial surface would be parallel to the applied force during the shear test.

Composition of the two sealants

The sealant in the Transbond XT adhesive system and used in group 1 (control) is made of the following ingredients: bisphenol A diglycidyl ether dimethacrylate (45– 55%), triethylene glycol dimethacrylate (45–55%), and DL-camphoquinone (<5%).

Pro Seal contains ethoxylated bisphenol A diacrylate (10–50%), urethane acrylate ester (10–40%), and polyethyleneglycol diacrylate (10–40%).

The exact percentages of both products are a trade secret.

Shear bond strength testing

Within half an hour from the initial bonding, an occlusogingival load was applied to each bracket, producing a shear force at the bracket-tooth interface. This was accomplished by using the flattened end of a steel rod attached to the crosshead of a Zwick Universal Test Machine (Zwick GmbH & Co, Ulm, Germany). A computer electronically connected to the Zwick test machine recorded the results of each test in megapascals. Shear bond strengths were measured at a crosshead speed of five mm/min.

Statistical analysis

Descriptive statistics, including the mean, standard deviation, and minimum and maximum values, were calculated for the three groups tested. One-way analysis of variance was used to determine if significant differences existed between the three groups compared. The significance for all statistical tests was predetermined at $P \leq .05$.

RESULTS Return to TOC

Comparisons of shear bond strengths

Analysis of variance (F-ratio = 1.35) indicated that the shear bond strengths of the three groups compared were not significantly different ($P = .267$) from each other (Table 1). The mean shear bond strength of the group 1 was 4.9 ± 2.1 MPa. The mean shear bond strength for the teeth coated with Pro Seal and light cured followed by placement and light curing of the bracket with the adhesive was 4.8 ± 2.3 MPa and for the teeth coated with Pro Seal and then bracket placed followed by simultaneous light curing of the sealant and the adhesive was 4.0 ± 1.5 MPa.

DISCUSSION Return to TOC

In this study, an attempt was made to determine whether applying a new highly filled protective sealant (Pro Seal) to the enamel surface would affect the shear bond strengths of orthodontic brackets. The findings indicated that the application of Pro Seal did not affect the shear bond strengths of the adhesive used within the first half hour after initial bonding. In other words, the shear bond strength was not significantly different whether the Pro Seal was light cured separately before the application of the adhesive or light cured simultaneously with the adhesive. The latter approach would save one step (10 s/tooth) during the bonding procedure if the clinician were interested in applying Pro Seal to the enamel surface in an attempt to minimize white spot lesion formation during orthodontic treatment.

Light curing the new protective sealant either separately or simultaneously with the orthodontic adhesive provided clinically acceptable shear bond strengths within the first 30 minutes after initial bonding. Powers and Messersmith[5] estimated that bonding materials that can resist shear forces of eight MPa are considered adequate for orthodontic use. It needs to be emphasized that the force levels in this study were obtained within the first half hour after bonding, when bond strength did not reach its maximum levels, which simulates the time when the initial archwires are ligated in the patient's mouth.

Future research should attempt to determine whether this product can prevent or decrease the incidence of white spot formation at the end of orthodontic treatment. Therefore, the fluoride release rate as well as the wear resistance of the sealant need to be independently evaluated.

CONCLUSIONS Return to TOC

In this study, the mean shear bond strengths of the groups tested with the new protective sealant and debonded within half an hour from initial bonding ranged from 4.0 to 4.9 MPa. The modifications introduced by the use of the Pro Seal protective sealant did not significantly influence the shear bond strength of the orthodontic brackets.

ACKNOWLEDGMENTS

The authors express their appreciation to Reliance Orthodontic Products Inc and 3M Unitek for supplying the materials used in this study.

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TABLE 1. Descriptive Statistics in Megapascals (MPa) and the Results of the Analysis of Variance of the Shear Bond Strength Between an Uncoated and Two Precoated Brackets

Bracket/Adhesive	n	$\bar{x}$	SD	Range
Group I (Control)	20	4.9	2.1	1.4–9.1
Group II (Pro Seal and adhesive light cured separately)	20	4.8	2.3	1.2–10.0
Group III (Pro Seal and adhesive light cured together)	20	4.0	1.5	1.3–6.3
F-ratio			1.35	
P			.267	

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