

A New Premixed Self-Etch Adhesive for Bonding Orthodontic Brackets

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ABSTRACT

Objective: To determine if a new premixed self-etch adhesive can be used to successfully bond orthodontic brackets to enamel.

Materials and Methods: Forty human molars were cleaned, mounted, and randomly divided into two groups. In group 1, 20 teeth were conditioned using the self-etching primer Transbond Plus (3M Unitek, Monrovia, Calif). In group 2, 20 teeth were conditioned using a new premixed self-etching adhesive, AdheSE One (Ivoclar Vivadent Inc, Amherst, NY). Both groups were bonded using brackets precoated with a composite adhesive. The teeth were debonded within half an hour following initial bonding using a universal testing machine. After debonding, the enamel surface was examined under 10 $\times$ magnifications to determine the amount of residual adhesive remaining on the tooth. A Student's *t*-test was used to compare the shear bond strength (SBS) of the two groups, and the Chi-square test was used to compare the adhesive remnant index (ARI) scores for the two adhesive systems.

Results: The mean SBS of the brackets bonded to the teeth using AdheSE One was 3.6 ± 1.3 MPa and was significantly lower ($t = 2.80$, $P = .01$) than the SBS of the brackets bonded using Transbond Plus ($\bar{x} = 5.9 \pm 3.2$ MPa). The comparisons of the ARI scores between the two groups ($\chi^2 = 19.26$) indicated that bracket failure mode was also significantly different ($P < .001$), with more adhesive remaining on the teeth bonded using Transbond Plus.

Conclusions: The SBS of the new premixed self-etching adhesive needs to be increased for it to be successfully used for bonding orthodontic brackets.

KEY WORDS: Premixed self-etch adhesive; Shear bond; Brackets

INTRODUCTION

Over the last 50 years the bonding of various adhesives to enamel and dentin has developed a niche in nearly all areas of dentistry, including orthodontics. Adhesion currently encompasses a combination of mechanical, adsorption, diffusion, and electrostatic phenomena.¹ Mechanical theories propose that ad-

hesion occurs primarily through microscopic interlocks between the adherend and the adhesive. The increase in the contact surface area between the two results in a greater number of "interlocks" and, thus, greater adhesive forces.

The clinical significance of utilizing these microscopic interlocks for bonding followed the introduction of the enamel acid-etch technique by Buonocore² in 1955. By demonstrating a 100-fold increase in retention of small polymethylmethacrylate buttons in teeth that had been etched with 85% phosphoric acid for 30 seconds, Buonocore opened the door to modern adhesive dentistry techniques.² Further studies determined that microporosities created during the acid-etching process allowed for the incorporation of small resin "tags" into the enamel surface, thereby creating microscopic mechanical interlocks between the enamel and resin.³⁻⁵

The traditional three-step etch/prime/adhesive procedure has been used for years to successfully bond orthodontic brackets to teeth. Since the depth of enamel dissolution during the etching process is of clinical importance, the potential use of alternative

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enamel conditioners has been studied in order to improve the bonding procedure by minimizing enamel loss and reducing chair time while still maintaining sufficient bond strengths between the brackets and enamel.⁶⁻⁸ While these new conditioners were initially developed for use on dentin, studies have determined that adhesive systems combining conditioning and priming can be successfully used to bond orthodontic brackets to enamel.⁹⁻¹¹ It has been demonstrated that shear bond strengths (SBSs) of brackets bonded using different "self-etch" primers (SEPs) were not significantly different from those associated with brackets bonded with the conventional acid-etch technique.^{9,11}

It has also been concluded that SEPs that produce a minimal etch pattern can still provide adequate bracket SBS.¹² Additionally, it was observed that when using a self-etching adhesive to bond brackets, no significant difference was seen when the SEP was cured either in separate steps or simultaneously with the bonding adhesive.¹³

A new self-etching adhesive, AdheSE One (Ivoclar Vivadent Inc, Amherst, NY), was introduced for use in operative dentistry. In a recent study, this self-etching adhesive provided microtensile bond strengths to enamel that were similar to those of three other self-etching adhesives currently available on the market.¹⁴ Although marketed for use in operative dentistry, it has been demonstrated that other restorative-based self-etching systems have been used successfully to bond orthodontic brackets.^{12,13} Unlike most self-etching systems, the AdheSE One offers the advantage of not having to be mixed prior to application. This in turn may reduce technique sensitivity by eliminating the chance of improper mixing and the resulting inadequate SEP activation.

Since no information is available with regard to whether AdheSE One can be used to bond orthodontic brackets, the purpose of this study was to determine if this new SEP can provide adequate SBS to be used for bonding orthodontic brackets.

MATERIALS AND METHODS

Teeth

Forty freshly extracted human molars were collected and stored in a solution of 0.2% (weight/volume) thymol. To meet the criteria for use in the study, the teeth were selected only if they had intact buccal enamel, had not been pretreated with chemical agents (eg, H₂O₂), had no surface cracks from extraction forceps, and were free of caries. The teeth were embedded in dental stone placed in phenolic rings (Buehler Ltd, Lake Bluff, Ill). A mounting jig was used to align the facial surfaces of the teeth perpendicular with the bottom of the mold. This kept the buccal surface of the

tooth parallel to the applied force during the shear test. Following mounting, the teeth were cleaned and polished with pumice and rubber prophylactic cups for 10 seconds.

Brackets

Orthodontic central incisor metal brackets (APC Plus Victory series, 3M Unitek, Monrovia, Calif) were used in this study. These brackets are precoated with a light-cured composite adhesive. Before bonding, the average surface area of the bracket base was determined to be 11.7 mm² by measuring six brackets.

Groups Tested

Group 1 (control). Twenty teeth were bonded using the manufacturer's recommended protocol. Transbond Plus SEP (3M Unitek) utilizes a loli-pop system that has two compartments: one contains methacrylated phosphoric acid esters, initiators, and stabilizers, whereas the other contains water, fluoride complex, and stabilizers. To activate the product, the two compartments are squeezed so that the contents of each compartment are allowed to mix. The resulting mix is then applied by continuously rubbing the SEP on the enamel surface for 3–5 seconds. The SEP is then lightly dried using compressed air for 1–2 seconds. Each precoated bracket was placed on the tooth and a 300-g force was applied (Correx force gauge, Bern, Switzerland) for 10 seconds. The force gauge is used to help assure a uniform adhesive thickness between the bracket and enamel. The bracket was then light cured using a Halogen curing light (Ortholux XT Curing Light, 3M Unitek) for 20 seconds (10 seconds for each proximal side).

Group 2. Twenty teeth were bonded, following the manufacturer's recommendations, using AdheSE One (Ivoclar Vivadent) as the self-etchant. This product does not need to be activated prior to use and comes in a pen form. AdheSE One contains derivatives of bis-acrylamide, water, bis-methacrylamide dihydrogen phosphate, amino acid acrylamide, hydroxy alkyl methacrylamide, highly dispersed silicon dioxide, catalysts, and stabilizers. The self-etchant is applied using a microbrush and is continuously brushed on each enamel surface for 30 seconds. A strong stream of air is then used to disperse excess etchant. The brackets were then applied as described for group 1 and were cured in a similar manner.

Debonding Procedure

The SBS of each group was determined within half an hour from the time of bonding to simulate the clinical conditions created when archwires are first tied to newly bonded teeth. A steel rod with a flattened end

Table 1. Descriptive Statistics in Megapascals (MPa) and the Result of the *t*-Test Comparison of the Two Groups Tested^a

Group	Self-Etchant	n	$\bar{x}$	SD	Range
1	Transbond Plus	20	5.9	3.2	1.1–11.3
2	AdheSE One	20	3.6	1.3	1.4–5.5

t-test = 2.80; *P* = .010

^a n indicates sample size; $\bar{x}$, mean; SD, standard deviation; and *P*, probability.

was attached to the crosshead of a Zwick testing machine (Zwick GmbH, Ulm, Germany). The rod applied an occlusogingival load to the bracket, producing a shear force at the bracket-tooth interface. The results of each test were recorded by a computer that was electronically connected to the testing machine. The Zwick machine (cell capacity = 50 KN) recorded the results from each test in megaPascals (MPa) at a crosshead speed of 5.0 mm/min.

Adhesive Remnant Index

Once the brackets were debonded, the enamel surface of each tooth was examined under 10× magnification to determine the amounts of residual adhesive remaining on each tooth. A modified adhesive remnant index (ARI) was used to quantify the amount of remaining adhesive using the following scale: 1 = all the adhesive remained on the tooth; 2 = more than 90% of the adhesive remained on the tooth; 3 = between 10% and 90% of the adhesive remained on the tooth; 4 = less than 10% of the adhesive remained on the tooth; and 5 = no adhesive remained on the tooth.

Statistical Analysis

A Student's *t*-test was utilized to determine whether there was a significant difference in SBSs between the two test groups, and the Chi-square (χ^2) test was used to compare the bond failure mode (ARI scores) between the two groups. For the purpose of statistical analysis, the ARI scores 1 and 2 as well as scores 4 and 5 were combined. Significance for all statistical tests was predetermined at *P* ≤ .05.

RESULTS

Shear Bond Strength

The descriptive statistics, including the mean, standard deviation, and minimum and maximum values, for the two bonding protocols are presented in Table 1. The mean SBS for the brackets bonded using Transbond Plus as the self-etchant was 5.9 ± 3.2 MPa, and the mean SBS for the brackets bonded using AdheSE One as the self-etchant was 3.6 ± 1.3 MPa. The *t*-test comparisons (*t* = 2.8) indicated that the SBSs of the brackets bonded using Transbond

Table 2. Frequency Distribution of the Modified Adhesive Remnant Index (ARI) Scores and χ^2 Comparisons of the Two Groups^a

Group	Self-Etchant	n	Modified ARI Scores ^b				
			1	2	3	4	5
1	Transbond Plus	20	6	3	4	6	1
2	AdheSE One	20	—	—	—	7	13

χ^2 = 19.26; *P* = < .001

^a n indicates sample size; *P*, probability.

^b 1 = All adhesive remained on the tooth; 2 = more than 90% of the adhesive remained on the tooth; 3 = 10%–90% of the adhesive remained on the tooth; 4 = less than 10% of the adhesive remained on the tooth; and 5 = no adhesive remained on the tooth.

Plus were significantly greater than those bonded using AdheSE One (*P* = .010).

Adhesive Remnant Index

The failure modes of the two groups are presented in Table 2. The χ^2 comparisons of the ARI scores between the two groups (χ^2 = 19.26) indicated that the two different SEPs had significantly different (*P* = < .001) bracket failure modes. All teeth bonded using AdheSE One had ARI scores of 4 and 5, indicating failure at the enamel/adhesive interface. In general, the teeth bonded using Transbond Plus had more adhesive remaining on the enamel surface following debonding.

DISCUSSION

Traditional methods of bonding orthodontic brackets to teeth have relied on the utilization of the acid-etch technique to achieve adequate retention. However, of primary concern to the clinician is the maintenance of a sound, unblemished enamel surface after the removal of brackets. SEPs were introduced in an effort to minimize enamel loss and also to reduce the bonding procedure from three to two steps, effectively decreasing technique sensitivity and reducing chair time. While typically designed for use in operative bonding procedures, SEPs have been used to successfully bond orthodontic brackets, with SBS values similar to those associated with the conventional acid-etch technique.⁹

This study evaluated whether a newly introduced self-etching adhesive used in restorative dentistry, AdheSE One, could provide acceptable SBS when used to bond orthodontic brackets. Unlike most self-etching systems, the AdheSE self-etching system offers the advantage of not having to be mixed prior to application, which makes the product relatively easy to use and eliminates the possibility of improper activation of the self-etchant. The new SEP requires no time to mix, but it needs to be applied for 30 seconds. Other SEPs require as few as 3–5 seconds per application.

The present findings indicated that the SBS of AdheSE One was significantly lower than that of the

control, Transbond Plus. The mean SBS of the brackets bonded using AdheSE One was 3.6 ± 1.3 MPa, and for the brackets bonded using Transbond Plus, this value was 5.9 ± 3.2 MPa. It has been suggested that a minimum SBS of 6.0–8.0 MPa is adequate for bonding orthodontic brackets to teeth.^{15,16} In this study, the mean SBS of AdheSE One was significantly below this value. However, from a clinical standpoint, the forces of the archwires used for initial leveling are, in general, less than those applied at a later point in treatment.

The present findings further indicated that the brackets bonded using AdheSE One failed in a different mode than those bonded using the Transbond Plus system. In general, bond failure for brackets bonded using AdheSE One occurred at the enamel/adhesive interface, while brackets bonded using Transbond Plus typically failed at the bracket/adhesive interface or within the adhesive. Bracket failure at each of the two interfaces has its own advantages and disadvantages. As an example, bracket failure at the bracket/adhesive interface is advantageous since it leaves the enamel surface relatively intact; however, considerable chair time is needed to remove the residual adhesive, with the added possibility of damaging the enamel surface during the cleaning process.¹⁷ On the other hand, when brackets fail at the enamel/adhesive interface, less residual adhesive remains, but the enamel surface can be damaged when failure occurs in this mode.¹⁸

Bracket failure typically occurs at the weakest link in the adhesive junction; for AdheSE One, the weakest link appears to be at the tooth/adhesive interface. To increase the SBS of AdheSE One the manufacturer might consider adding more conditioner/etchant to the adhesive; this would most likely strengthen the bond at the tooth interface.

CONCLUSIONS

- The SBS of a traditional SEP system used for bonding orthodontic brackets had significantly greater SBS than that of AdheSE One, a self-etching system used in restorative dentistry.
- Bracket failure modes were also different between the two adhesive systems.
- The manufacturer should consider changes in the composition of AdheSE One self-etching adhesive for it to be potentially useful for successfully bonding orthodontic brackets to enamel.

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