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Evaluation of Nonrinse Conditioning Solution and a Compomer as an Alternative Method of Bonding Orthodontic Bracket

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ABSTRACT

Damage to the enamel surface during bonding and debonding of orthodontic brackets is a clinical concern. Alternative bonding methods that minimize enamel surface damage while maintaining a clinically useful bond strength are an aim of current research. The purpose of this study was to compare the effects of using two enamel conditioners and adhesives on the shear bond strength and bracket failure location. Forty freshly extracted human molars were pumiced and randomly divided into two groups of 20 teeth. Metal orthodontic brackets were bonded to the enamel surface by one of two protocols: 37% phosphoric acid with a composite adhesive (Transbond XT) or a nonrinse conditioner with a compomer adhesive (Dyract flow). The teeth were mounted in phenolic rings and stored in deionized water at 37°C for 24 hours. A Zwick Universal Testing Machine was used to determine shear bond strengths in MegaPascals. The residual adhesive on the enamel surface was evaluated using the Adhesive Remnant Index. Student *t*-test and X^2-test were used to compare the two groups. Significance was predetermined at $P \leq .05$. The results of the *t*-tests indicated that there were significant differences between the two adhesive systems ($t = 11.18$ and $P = .001$) with the nonrinse conditioner/compomer system having lower shear bond strength ($\bar{X} = 1.7 \pm 0.9$ MPa) than the phosphoric acid/composite adhesive ($\bar{X} = 10.4 \pm 2.8$ MPa). The results of the Chi Square test evaluating the residual adhesives on the enamel surfaces also revealed significant differences between the two groups ($X^2 = 7.62$, $P = .022$). In conclusion, a nonrinse conditioner used with a compomer adhesive had significantly lower shear bond strength than a phosphoric acid/composite adhesive system.

KEY WORDS: Nonrinse conditioner, Compomer, Composite, Brackets, Shear bond strength.

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INTRODUCTION Return to TOC

Direct bonding of orthodontic brackets has resulted in an improved oral environment[1–8] due to: an enhanced ability for plaque removal by the patient, minimized soft tissue irritation and hyperplastic gingivitis,[5,9] elimination of the need for separation, absence of posttreatment band spaces, facilitation of application of attachments to partially erupted teeth, minimizing the danger of decalcification with loose bands,[9,10] easier detection and treatment of caries, and providing the patient with a more esthetic orthodontic appliance.[2].

Buonocore[11] introduced the acid-etch technique in 1955 by bonding acrylic resin to the enamel surface that had been pretreated with

85% phosphoric acid for 60 seconds. Since this initial report, various investigators have evaluated the technique to determine the factors that may affect the strength of the mechanical bond, including the type of enamel conditioner,[11–14] acid concentration,[15–20] and length of etching time.[19,20–23]

Phosphoric acid has remained the primary etchant since its initial introduction by Buonocore. Studies indicated that a phosphoric acid concentration between 30% to 40% results in the most retentive etching pattern.[16,17] Current clinical use of phosphoric acid utilizes 35% to 37% acid concentration. Other studies have examined the effect of etching time on the overall bond strength and concluded that etching for more than 60 seconds resulted in over dissolution of the enamel surface and a decrease in bond strength.[22] Furthermore, a clinically useful bond strength was maintained even when the etching time was reduced to as low as 10 seconds.[24] Current clinical techniques utilize an etching time between 15 and 60 seconds.

Cerehli and Altay[25] evaluated the effect of different acid etching solutions on the etch pattern of human enamel and concluded that regardless of treatment time, etching with 37% phosphoric acid results in irreversible damage to the enamel surface.

As a result, other bonding systems were designed to use an enamel and dentin conditioner that consists of 10% maleic acid thickened with polyvinyl alcohol. Barkmeier et al[26] and Triolo et al[27] compared the use of maleic acid to phosphoric acid. Their results indicated that 10% maleic acid provides bond strengths essentially equal to that of 37% phosphoric acid. Scanning electron microscopy of the enamel surfaces treated with 10% maleic acid and 37% phosphoric acid revealed a similar morphologic pattern but the depth of the etched surface was significantly less with maleic acid.

Currently, there is a trend that favors the use of a new generation of hybrid materials that contain both resin and glass ionomer and release fluoride ions.[28] According to Cerehli and Altay,[25] one of these materials is the light activated product Dyract Orthodontic (DeTrey Dentsply, Konstanz, Germany) and belongs to a new class of materials named polyacid modified resin composites or compomers.[29] Essentially, compomers contain a glass ionomer cement but at levels that are insufficient to produce an acid base reaction in the dark. The curing of compomers depend solely on photopolymerization, whereas the acid base reaction initiated by water from the oral environment is responsible for the fluoride release.[30] On the other hand, resin modified glass ionomer cements retain a significant acid base reaction as part of their overall curing process with initial hardening that depends on photoactivation.[29] Major compositional differences between these two classes of hybrid materials could, therefore, explain the adequate bond strength of the resin modified glass ionomer with no enamel pretreatment,[31] whereas a composite resin requires enamel etching with phosphoric acid.[32,33] Cerehli and Altay[25] found that using a nonrinse conditioning (NRC) solution produced a smooth yet “adequately rough” enamel surface without a need for prolonged etching time. They also observed that these alterations are limited to the surface with no damage to the enamel prisms. As a result, they suggested treating the enamel with NRC and bonding the brackets with a compomer adhesive.

Maintaining a sound unblemished enamel surface at the time of debonding of brackets is a primary clinical concern to orthodontists. As a result, an alternative conditioner, such as maleic acid, that can maintain a clinically useful bond strength while decreasing the depth of enamel dissolution[26,27], may minimize the depth of enamel surface damage at the end of orthodontic treatment.

The purpose of this study was to compare the effects of using different enamel conditioners and adhesives on the shear bond strength and to identify bracket/adhesive failure locations.

MATERIALS AND METHODS Return to TOC

Teeth

Forty freshly extracted human molars were collected and stored in a solution of 0.1% (weight/volume) thymol. The criteria for tooth selection included: intact buccal enamel, not subjected to any pretreatment chemical agents (eg, hydrogen peroxide), no cracks due to the presence of the extraction forceps, and no caries. The teeth were cleansed and then polished with pumice and rubber prophylactic cups for 10 seconds. The surface enamel was left intact.

Brackets

Orthodontic metal brackets for the maxillary central incisors (Victory Series. 3M Unitek, Monrovia, CA) were used in this study. The average bracket base surface area was determined to be 11.5 mm.[2]

Bonding procedure

The teeth were randomly divided into two groups and the brackets were bonded to the buccal surface of the teeth following the manufacturer's instructions according to one of two protocols:

Group I: Bonding with Transbond XT (3M Unitek, Monrovia, Cal): 20 teeth were etched with 37% phosphoric acid gel for 30 seconds. The teeth were thoroughly washed and dried. The sealant was applied to the enamel; the adhesive was applied to the brackets which were then placed on the teeth and light cured for 20 seconds.

Group II: Bonding with NRC/Dyract flow (DeTrey Dentsply, Konstanz, Germany): the tooth surface was cleaned using a rubber cup and pumice. The surface was washed thoroughly with an air and water spray. Excess water was removed by blotting dry with a cotton pellet to avoid dissicating the enamel surface. NRC is nonrinse conditioning solution (NRC, DeTrey Dentsply, Konstanz, Germany) that etches enamel without further rinsing but needs to be air dried for 5 seconds. NRC contains organic acids (maleic acid) and monomers in an aqueous base.[34] NRC was applied to the enamel surface with an applicator tip and left for 20 seconds. Excess NRC was removed either by blowing gently with an air syringe or blotting with a cotton pellet. Dyract flow was applied from the syringe directly on the bracket and the bracket was then placed on the tooth. The adhesive was light cured for 40 seconds.

In both test groups, each bracket was subjected to a 300-gram compressive force using a force gauge (Correx Co, Bern, Switzerland) for 10 seconds, following which excess bonding resin was removed using a sharp scaler. The same clinician bonded all teeth. The teeth were then placed in deionized water at 37°C for 24 hours.

Debonding procedure

The teeth were embedded in acrylic in phenolic rings (Buehler, Ltd, Lake Bluff, Ill). A mounting jig was used to align the facial surface of the tooth perpendicular with the bottom of the mold. Each tooth was oriented with the testing device as a guide, so its labial surface was parallel to the force during the shear strength test. A steel rod with one flattened end was attached to the crosshead of a Zwick test machine (Zwick Gm bH & Co, Ulm, Germany). An occluso-gingival load was applied to the bracket producing a shear force at the bracket-tooth interface. A computer, electronically connected with the Zwick test machine, recorded the results of each test. Shear bond strengths were measured at a crosshead speed of 5 mm/min.

Residual adhesive

After debonding, the teeth and brackets were examined under 10× magnification. Any adhesive remaining after bracket removal was assessed according to the modified Adhesive Remnant Index (ARI) and scored with respect to the amount of resin material adhering to the enamel surface.[35] The ARI scale has a range between 5 and 1, with 5 indicating that no composite remained on the enamel; 4, less than 10% of composite remained on the tooth surface; 3, more than 10% but less than 90% of the composite remained on the tooth; 2, more than 90% of the composite remained; and 1, all of the composite and the impression of the bracket base remained on the tooth. The ARI scores were also used as a more complex method of defining the site of bond failure between the enamel, the adhesive, and the bracket base.

Statistical analysis

Descriptive statistics including the mean, standard deviation, and minimum and maximum values were calculated for each of the two test groups. Student *t*-test was used to determine if significant differences were present in the shear bond strength between the two groups. The Chi Square test was also used to determine significant differences in the ARI scores between the groups. Significance for all statistical tests was predetermined at $P = .05$.

RESULTS Return to TOC

Shear Bond Strength Comparisons

The descriptive statistics for the shear bond strengths of the two groups are presented in Table 1. The results of the Student *t*-test indicated that the NRC/compomer adhesive system had a significantly ($t = 11.18$, $P = .001$) lower shear bond strength ($\bar{X} = 1.7 \pm 0.9$ MPa) than the conventional composite adhesive system ($\bar{X} = 10.4 \pm 2.8$ MPa).

Adhesive Remnant Index (ARI) Comparisons

The results of the Chi square comparisons indicated that there was a significant difference ($X^2 = 7.62$, $P = .022$) between the two groups (Table 2). With the use of the NRC/compomer, there was a higher frequency of ARI score of 3, indicating a more cohesive failure mode.

DISCUSSION Return to TOC

The direct bonding of orthodontic brackets has revolutionized and improved the clinical practice of orthodontics. Traditionally, the use of acid etchants followed by a primer was an essential part of the bonding procedure of composite adhesives in order to allow good wetting and penetration of the sealant into the enamel surface.[26,27] The goal of current orthodontic research is to improve the bonding procedure by minimizing enamel loss during bonding and debonding without jeopardizing the ability to maintain a clinically useful bond strength. The use of self-etching primers for orthodontic purposes were thought to simplify the clinical handling of adhesive systems by combining the etchant and the primer in one application.[36–38] The earlier generation of acidic primers were selectively compatible with different adhesives and, as a result, they either produced significantly lower bond strength or needed significantly more working time.[38] On the other hand, the newer generation of self-etch primers are compatible with composite and compomer adhesives and may have adequate strength to bond orthodontic brackets.[25,39] By reducing the number of steps during bonding, clinicians are able to save time and reduce the potential for error through contamination during the bonding procedure.

CONCLUSIONS Return to TOC

The present study evaluated the performance of a 2-component adhesive system (nonrinse conditioner/compomer), and compared it to a conventional 3-component system (phosphoric acid/sealant/composite) adhesive. The findings indicated that the use of the nonrinse conditioner/compomer adhesive to bond orthodontic brackets did not provide the clinically acceptable shear bond force levels suggested by Reynolds (5.0–7.0 MPa).[40] As a result, other combinations of nonrinse conditioners and compomer/composite adhesives need to be evaluated.

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TABLES Return to TOC

TABLE 1. Descriptive Statistics and Results of the Student t-test Comparing the Shear Bond Strengths in MegaPascals (MPa) of the Two Groups Evaluated

Groups Tested	$\bar{x}$	SD	Range
Phosphoric acid + sealant + composite	10.4	2.8	6.4–19.1
Nonrinse primer + compomer	1.7	0.9	0.1–3.7
	t-value = 11.18		
	P = .001		

$\bar{x}$ indicates mean; SD, standard deviation; *P*, probability.

TABLE 2. Frequency Distribution and the Results of the Chi Square Analysis of the Modified Adhesive Remnant Index (ARI) of the Two Groups Evaluated

Groups Tested	ARI Scores*				
	1	2	3	4	5
Phosphoric acid + sealant + composite	1	7	7	4	1
Nonrinse primer + compomer	1	5	14	—	—
	$X^2 = 7.62$				
	P = .022				

* 1, indicates all of composite on tooth; 2, >90% of composite on tooth; 3, >10% but <90% of composite on tooth; 4, <10% of composite on tooth, 5 = no composite remains on tooth.

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