Original Article

Evaluation of Modifying the Bonding Protocol of a New Acid-Etch Primer on the Shear Bond Strength of Orthodontic Brackets

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Abstract: The purpose of the study was to evaluate the shear bond strength of orthodontic brackets when light curing both the self-etch primer and the adhesive in one step. Fourty eight teeth were bonded with self-etch primer Angel I (3M/ESPE, St Paul, Minn) and divided into three groups. In group I (control), 16 teeth were stored in deionized water for 24 hours before debonding. In group II, 16 teeth were debonded within half-an-hour to simulate when the initial archwires were ligated. In group III, 16 additional teeth were bonded using exactly the same procedure as in groups I and II, but the light cure used for 10 seconds after applying the acid-etch primer was eliminated, and the light cure used for 20 seconds after the precoated bracket was placed over the tooth. This saved at least two minutes of the total time of the bonding procedure. The teeth in this group were also debonded within half-an-hour from the time of initial bonding. The teeth debonded after 24 hours of water storage at 37°C had a mean shear bond strength of 6.0 ± 3.5 MPa, the group that was debonded within half-an-hour of two light exposures had a mean shear bond strength of 5.9 ± 2.7 MPa, and the mean for the group with only one light cure exposure was 4.3 ± 2.6 MPa. Light curing the acid-etch primer together with the adhesive after placing the orthodontic bracket did not significantly diminish the shear bond strength as compared with light curing the acid-etch primer and the adhesive separately. (*Angle Orthod* 2004;74:410–413.)

Key Words: Acid-etch primer; Brackets; Light cure time; Shear bond strength

INTRODUCTION

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

Bounocore[11] introduced the acid-etched technique in 1955 by bonding acrylic resin to the enamel surface pretreated with 85% phosphoric acid for 60 seconds.[11] Since this initial report, various investigators have evaluated the technique to determine the factors that might affect the strength of the mechanical bond including the type of enamel conditioner,[11–14] acid concentration,[15–21] and length of etching time.[19,21–24]

Phosphoric acid has remained the primary etchant since its initial introduction by Bounocore. Studies indicated that a phosphoric acid concentration of between 30% to 40% results in the most retentive etching pattern.[16,17] For most current clinical phosphoric acid applications, a 37% acid concentration is used.

Orthodontists use the acid-etch bonding technique as a primary means of attaching brackets to the enamel surface. Maintaining a sound unblemished enamel surface is a primary clinical concern when debonding the brackets after orthodontic treatment. Enamel fracture and cracks have been reported at the time of bracket debonding.[2] It is possible that the depth of the etched enamel surface created by

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phosphoric acid may be a contributing factor to the incidence of enamel fracture.[25–27] Therefore, to minimize the extent of enamel surface damage, alternative conditioners, such as maleic acid, have been used to obtain clinically useful bond strengths by decreasing the depth of enamel dissolution.

With the introduction of the new acid-etch primers that combine both the acid etchant and the primer or adhesive, it became possible for the clinician to both eliminate one of the steps during the bonding procedure and minimize the amount of enamel lost during etching.[27]

This is because the new acid-etch primers do not penetrate or dissolve the enamel surface to the same depth as conventional systems that use phosphoric acid.[27]

The acid-etch primer should be light cured during its application. When the bracket with the adhesive is placed on the tooth, the light curing needs to be repeated. It might be of interest to clinicians to determine whether it is possible to apply the curing light only at one time, ie, to cure both the acid-etch primer and the adhesive at the end of the bonding procedure, thereby saving chairside time.

The purpose of this study was to evaluate the effect on the shear bond strength of light curing the self-etch primer and the bracket adhesive in one step.

MATERIALS AND METHODS

Teeth

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

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 in order for it to be perpendicular with the bottom of the mold. Each tooth was oriented with the testing device as a guide so that its labial surface was parallel to the force during the shear strength test.

Brackets used

Stainless steel metal brackets precoated with the APC II adhesive (Victory series, 3M Unitek, Monrovia, Calif) were used. The mean area of the bracket base surface was 11.8 mm^2.

Bonding procedure

The brackets were bonded to the teeth according to one of three protocols. A total of 48 teeth were bonded with the new self-etch primer Angel I (3M/ESPE, St Paul, Minn). The material containing both the acid and the primer was applied to the enamel for 15 seconds, gently evaporated with air, and light cured for 10 seconds according to the manufacturer's instructions. The material comes in a lollipop package and is predosed so that it is used for only one application. The unidose system in Angel I has two compartments: one contains methacrylated phosphoric acid esters, initiators, and stabilizers, whereas the other contains water, fluoride complex, and stabilizers. For activation, the two compartments are squeezed into each other, and the resulting mix can be applied directly on the tooth surface. The precoated brackets were then bonded and light cured for 20 seconds. These teeth were then randomly divided into two groups:

- Group I (control): 16 teeth were stored in deionized water for 24 hours before debonding.
- Group II: 16 teeth were debonded within half-an-hour to simulate the time when the initial archwires are ligated after initial bonding.

In group III, 16 additional teeth were bonded using exactly the same procedure as in groups I and II but with one exception. Instead of light curing for 10 seconds after the acid-etch primer was applied, this step was eliminated, and the light cure was used after the precoated bracket was placed over the tooth for a total of 20 seconds. This approach could potentially save the clinician at least two minutes from the total time of the bonding procedure.[26]

In all groups, after bracket placement on the tooth and before light curing, the bracket was subjected to a 300-g compressive force using a force gauge (Correx Co., Bern, Switzerland) for 10 seconds, after which excess bonding resin was removed using a sharp scaler.

Debonding procedure

A steel rod with one flattened end was attached to the crosshead of a Zwick test machine (Zwick GMBH, Ulm, Germany). An occlusogingival 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 five mm/minute.

Statistical analysis

Descriptive statistics including the mean, standard deviation, minimum and maximum values were calculated for each of the three test groups. The analysis of variance was used to determine if significant differences were present in the bond strength between the groups. If significant differences were present, Tukey's honestly significantly different (HSD) posterior tests were used to determine which of the means were significantly different from each other. Significance for all statistical tests was predetermined at $P \leq .05$.

TABLE 1. Descriptive Statistics (in MPa) and Results of the Analysis of Variance Comparing the Three Groups Tested[a]

Groups Tested	$\bar{x}$	SD	Range	Tukey HSD[b]
Debonding after 24 h	6.0	3.5	1.8–13.3	A
Debonding after 0.5 h				
Two light cure exposures (30 s)	5.9	2.7	0.8–9.5	A
One light cure exposure (20 s)	4.3	2.6	0.9–9.8	A
	$F = 1.658$ $P = .203$			

[a] $\bar{x}$ indicates mean shear bond strength; HS, honestly significantly different.

[b] Groups with the same letter are not significantly different from each other.

RESULTS

The descriptive statistics for the shear bond strengths of the three groups are presented in Table 1. The results of the analysis of variance ($F = 1.658$) indicated that the shear bond strengths of the three groups were not significantly different ($P = .203$). The teeth debonded after 24 hours of storage in water at 37°C had a mean shear bond strength of 6.0 ± 3.5 MPa, whereas the group that was debonded within half-an-hour after two light exposures had a mean shear bond strength of 5.9 ± 2.7 MPa, and the mean for the group with only one light cure exposure was 4.3 ± 2.6 MPa.

DISCUSSION

The direct bonding of orthodontic brackets has revolutionized and improved the clinical practice of orthodontics. However, the reported incidents of enamel fracture during debonding ceramic brackets has raised concerns regarding the effects of phosphoric acid on enamel.[28,29]

In the process of bonding orthodontic brackets to enamel, most conventional adhesive systems use three different agents: an enamel conditioner, a primer solution, and an adhesive resin. Acid conditioning of enamel with 35–37% phosphoric acid has been the most effective method for enhancing the bonding of adhesive resin composite restorative materials to enamel.[17] Acid etching results in microporosities in the enamel surface, into which the adhesive can penetrate to produce micromechanical retention of the restoration and increase the bondable surface area.[15–17] In addition to creating microporosities, the conditioner agent removes the organic film from the tooth surface so that a more direct contact is established at the tooth restorative interface.

As a result, there is a need to improve our ability to maintain clinically useful bond strength while minimizing the amount of tooth destruction, whether by fracture or by decalcification. A unique characteristic of some new bonding systems in operative dentistry is that these systems combine the conditioning and priming agents into a single acidic primer solution for simultaneous use on both enamel and dentin.[25,30] Current data suggest that the new self-etch adhesive systems have comparable bond strength with those of conventional systems, resulting in a strong and predictable bond to the tooth surface. Therefore, the introduction of these new tooth preparation technologies, along with the development of new simplified one-step self-etching adhesive systems, may result in more efficient and conservative ways of achieving predictable bonding to tooth structure.[27]

Aljuburi et al[26] calculated the time it took to bond 30 premolar teeth in the laboratory using conventional bonding as compared with bonding with a self-etch primer. They found that with conventional bonding, the time was 170 seconds, whereas using an acid-etch primer bonding, the time was 111 seconds. The difference of 59 seconds was statistically significant. On the other hand, the cleaning time after debonding was not different between the two approaches.

In the present study, by light curing both the self-etch primer and the adhesive simultaneously, the clinician can potentially achieve an additional 10-second reduction in the bonding time for each tooth. During routine bonding procedures involving 20 teeth, such reduction in working time would amount to at least 200 seconds or 3+ minutes per patient.

CONCLUSIONS

The findings from the present study indicate that light curing the acid-etch primer together with the adhesive after placing the orthodontic bracket did not significantly affect the shear bond strength when compared with light curing the acid-etch primer and the adhesive separately. This approach eliminates one step in the bonding procedure and could potentially save the clinician chairside time.

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