Original Article

Effects of Self-Etching Primer on Shear Bond Strength of Orthodontic Brackets at Different Debond Times

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ABSTRACT

Objective: To evaluate the effect of a self-etching primer on shear bond strengths (SBS) at the different debond times of 5, 15, 30, and 60 minutes and 24 hours.

Materials and Methods: Brackets were bonded to human premolars with different etching protocols. In the control group (conventional method [CM]) teeth were etched with 37% phosphoric acid. In the study group, a self-etching primer (SEP; Transbond Plus Self Etching Primer; 3M Unitek, Monrovia, Calif) was applied as recommended by the manufacturer. Brackets were bonded with light-cure adhesive paste (Transbond XT; 3M Unitek) and light-cured for 20 seconds in both groups. The shear bond test was performed at the different debond times of 5, 15, 30 and 60 minutes and 24 hours.

Results: Lowest SBS was attained with a debond time of 5 minutes for the CM group (9.51 MPa) and the SEP group (8.97 MPa). Highest SBS was obtained with a debond time of 24 hours for the CM group (16.82 MPa) and the SEP group (19.11 MPa). Statistically significant differences between the two groups were not observed for debond times of 5, 15, 30, or 60 minutes. However, the SBS values obtained at 24 hours were significantly different ($P < .001$).

Conclusions: Adequate SBS was obtained with self-etching primer during the first 60 minutes (5, 15, 30 and 60 minutes) when compared with the conventional method. It is reliable to load the bracket 5 minutes after bonding using self-etching primer (Transbond Plus) with the light-cure adhesive (Transbond XT).

KEY WORDS: Self-etching primer; Debond time; Bond strength

INTRODUCTION

The conventional method for bonding orthodontic brackets to the enamel surface necessitates three different agents: an enamel conditioner, a primer solution, and an adhesive resin. Phosphoric acid solution is the most widely used enamel conditioner. It was reported that a phosphoric acid concentration of 30% to 40% results in the most retentive etching pattern.[1]

The introduction of the new acid-etch primers has attracted considerable interest, because they combine the etching and priming steps into one, eliminating the need to rinse and possibly avoiding damage to the gingival tissue. Furthermore, it has been reported that they minimize the amount of enamel lost during etching.[2,3]

Prompt L-Pop was the first sixth-generation adhesive to be released on the dental market.[4] The same chemical composition was employed in the new self-etching primer (Transbond Plus Self Etching Primer; 3M Unitek, Monrovia, Calif) for orthodontics.

Numerous in vitro studies were published concerning the effectiveness of this new self-etching primer.[5–13] These studies reported contradictory results. A difference in bond strength of orthodontic brackets between the enamel treated with the self-etching primer and by the conventional method was not observed.[5,8–10,12] However, Aljubouri et al[6] and Grubisa et al[11] observed significantly lower shear bond strength (SBS) with the self-etching primer, whereas Buyukyilmaz et al[7] and Bishara et al[13] reported significantly higher SBS values.

In most of these studies, the efficacy of Transbond

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Plus Self Etching Primer was evaluated 24 hours after the bonding procedure.[5–8,10] Testing at 24 hours is generally preferred because it has been widely reported, and allows comparison with other in vitro bond strength studies.[6] Furthermore, polymerization is expected to be complete at the end of 24 hours.[14]

However, this time period of 24 hours does not reflect clinical orthodontic practice, in which the archwire is usually placed after bracket bonding.[15,16] In orthodontic practice, the time span from bracket bonding to initial archwire insertion varies according to the number of teeth being bonded and the experience of the clinician. Initial bond strength of orthodontic attachment is highly important because most orthodontists insert the archwire into the bracket slot from 10 to 15 minutes after bonding.[17] To simulate clinical practice, the bond strengths of orthodontic brackets were measured at 2.5, 5, 10, 15, and 30 minutes.[14,16,18] Nevertheless, a limited number of studies do exist concerning the SBS of Transbond Plus self-etching primers during the first 30 minutes.[12,13,19] Two studies[12,13] have reported bond strengths at 30 minutes, and one study[19] presented bond strengths at 5 and 15 minutes.

The aim of the present study was to evaluate the effect of Transbond Plus Self Etching Primer on the SBS of orthodontic brackets within 5, 15, 30, and 60 minutes and 24 hours.

MATERIALS AND METHODS

Teeth

One hundred human maxillary premolar teeth were included in this study. The teeth were stored in distilled water after extraction and the water was changed weekly to avoid bacterial growth.[7] The inclusion criteria for the selection of the teeth included intact buccal enamel, the absence of pretreatment with chemical agents (such as hydrogen peroxide) and the absence of cracks and caries.

Each tooth was embedded into a cold-cure acrylic resin (Orthocryl; Dentaurum, Ispringen, Germany) cylindrical block. A jig was used to align the buccal surface of each tooth parallel to the cylinder's base. The teeth were cleansed and polished with pumice and rubber prophylactic cups for 10 seconds. The sample was randomly divided into two groups of 50 teeth each.

Brackets Used

Stainless steel premolar brackets (Gemini bracket; 3M Unitek) were used. The mean area of each bracket base was 10.62 mm^2.

Bonding Procedure

The brackets were bonded according to one of the following two protocols:

In the control group (conventional method [CM]), the teeth were etched with 37% phosphoric acid for 30 seconds, washed for 20 seconds, and dried for 10 seconds. After etching, a thin uniform coat of primer (Transbond XT Primer; 3M Unitek) was applied. The adhesive resin (Transbond XT Light Cure Adhesive Paste; 3M Unitek) was placed onto the bracket base and the bracket was positioned on the enamel surface. Excess adhesive resin was removed with an explorer. Adhesive resin was polymerized for a total of 20 seconds from two directions using a visible light-curing unit (Hilux 200; Benlioglu Dental Inc, Ankara, Turkey) with an output power of 600 mW/cm^2.

In the experimental group (self-etching primer [SEP]) Transbond Plus Self Etching Primer (3M Unitek) was applied to the enamel surface and rubbed for 3 seconds. Then, a gentle burst of dry air was delivered to thin the primer. The bonding procedure with Transbond XT adhesive resin was performed as for the CM group.

Debonding Procedure

After the brackets had been bonded to the enamel surface with two different etching procedures, each group was divided into five subgroups (each containing 10 teeth) according to debonding time: 5, 15, 30, and 60 minutes and 24 hours.

Two minutes after bonding, the specimens were stored in distilled water (37°C) to prevent dehydration.

The shear bond test was performed with a universal testing device (Lloyd LRX; Lloyd Instruments Ltd., Fareham, UK) at a crosshead speed of 1 mm/minute. The bond strengths were calculated in megapascals (MPa).

Residual Adhesive

The enamel surfaces were examined with a stereomicroscope (Stemi 2000-C; Carl Zeiss, Göttingen, Germany) at a magnification of 10× to determine the amount of composite resin remaining according to the adhesive remnant index (ARI).[20] The ARI scale has a range from 0 to 3, with 0 indicating no composite left on the enamel; 1, less than half of the composite left; 2, more than half of the composite left; 3, all composite left on the tooth surface.

Statistical Analysis

Two-way analysis of variance was used to obtain the significant differences among etching protocols and debond times and their interactions. All treatment

Table 1. Two-Way Analysis of Variance of Force (MPa) Required to Debond Metal Brackets From Enamel Surface

Source of variation	Sum of squares	df	Mean square	F ratio	Significance
Etching protocol	1.717	1	1.717	0.330	.567
Debonding time	937.071	4	234.268	45.002	.000
Etching protocol × debonding time	35.201	4	8.800	1.691	.159
Error	468.511	90	5.206		
Corrected total	1442.501	99			

Table 2. Mean Shear Bond Strengths, Standard Deviations (SD), and Minimum (Min) and Maximum (Max) Values for Each Group (n = 10)[a]

Group	Mean	SD	Min	Max	Scheffé*
CM 24 h	16.82	3.02	11.27	21.08	A
CM 60 min	12.32	2.26	8.05	15.56	B
CM 30 min	11.24	2.16	9.69	15.99	B
CM 15 min	10.75	2.26	7.25	15.64	B
CM 5 min	9.50	1.52	7.03	11.63	B
SEP 24 h	19.11	3.40	14.68	24.72	A
SEP 60 min	13.13	2.09	8.48	16.16	B
SEP 30 min	10.15	1.97	7.07	13.15	B
SEP 15 min	10.61	1.34	8.33	12.21	B
SEP 5 min	8.97	2.05	6.95	13.46	B

[a] Means for groups having the same letters show homogeneous subsets. Scheffé indicates Scheffé multiple comparisons test; CM, conventional method (37% phosphoric acid); and SEP, self-etching primer.

* Significance level $P < .05$.

combination means for bond strength values were compared by using the post hoc Scheffé multiple comparison test ($P < .05$). The chi-squared test was also used to determine significant differences for the ARI scores among the groups ($P < .05$).

RESULTS

Results of the 2-way analysis of variance used to obtain the significant differences among etching protocols and debond times and their interactions are shown in Table 1. The main effects show a significant difference between debond times for bond strength values ($P < .001$). However, neither a significant difference for etching protocols nor a significant interaction between the debond time and etching protocols was observed ($P > .05$). The mean SBS, minimum and maximum values, and standard deviations for each group are given in Table 2. The results of the Scheffé multiple comparisons test to compare the mean SBS are given in Table 2.

Lowest bond strengths were attained with a debond time of 5 minutes for the CM group (9.51 MPa) and the SEP group (8.97 MPa). The bond strengths increased with increased time. Highest bond strengths were obtained with debond times of 24 hours for the CM group (16.82 MPa) and the SEP group (19.11 MPa). Statistically significant differences were not observed for the debond times of 5, 15, 30 and 60 minutes for both groups. However, SBS values obtained at 24 hours were found significantly different from SBS values obtained at 5, 15, 30, and 60 minutes for both groups.

Table 3. Frequency Distribution and the Result of the Chi-Square Analysis of the Adhesive Remnant Index (ARI)[a]

	ARI score[b]			
Group	0	1	2	3
CM 24 h	2	6	1	1
CM 60 min	—	2	2	6
CM 30 min	—	—	2	8
CM 15 min	—	2	1	7
CM 5 min	—	1	1	8
SEP 24 h	—	1	4	5
SEP 60 min	2	6	—	2
SEP 30 min	—	1	3	6
SEP 15 min	2	3	3	2
SEP 5 min	—	3	3	4

* $\chi^2 = 48.42$, $P = .007$. CM indicates conventional method (37% phosphoric acid); SEP, self-etching primer.

[b] ARI scores: 0, no composite left on enamel surface; 1, less than half of composite left; 2, more than half of composite left; and 3, all composite left.

Frequency distribution and the result of the chi-square analysis of the ARI are given in Table 3. The results of the chi-squared comparisons indicated that there was a significant difference ($P < .007$) for the groups. With the use of 37% phosphoric acid, there was a higher frequency of ARI scores of 3.

DISCUSSION

The mean SBS was higher in the SEP group (19.11 MPa) than in the CM group (16.82 MPa) at 24 hours. However, this difference was not statistically significant. Buyukyilmaz et al[7] obtained a higher SBS with the self-etching primer than with phosphoric acid etching at 24 hours. Self-etching primers do not dissolve as much hard tissue, ie, enamel, as phosphoric acid.[2] Even though a shallower etch pattern is present, the combination of the etchant and the primer in one application ensures the penetration of the primer for the entire depth of the etch, resulting in an excellent mechanical interlock.[2,7,8,21]

For both groups, SBS values obtained during the first 60 minutes (at 5, 15, 30, and 60 minutes) were significantly less than at 24 hours. This finding seems inevitable because 24 hours has been stated to be the time when the composite reaches its maximum strength.[14,18] Our results corroborate this statement. However, SBS values obtained during the first 60 minutes (5, 15, 30, and 60 minutes) were not significantly

different between the groups. In the SEP group, the mean SBS at 5 (8.97 MPa) and at 15 (10.61 MPa) minutes is in agreement with the results of Movahhed et al[19] (8.8 MPa and 11.0 MPa, respectively). In the SEP group, the SBS at 30 minutes (10.15 MPa) is similar to the result of Bishara et al[13] (9.4 MPa). However, Bishara et al[13] found a significant difference between the self-etching primer (Transbond Plus) and the conventional Transbond XT bonding system (6.2 MPa). In another study by Bishara et al,[12] a SBS of 5.9 MPa at 30 minutes was reported.

SBS with Transbond Plus Self-Etching Primer and Transbond XT Light Cure Adhesive Paste demonstrated a large range of bond strengths (2.8 MPa to 16.0 MPa).[5–8,10] Variation in bond strengths, even though an identical adhesive system was applied in different studies, may be attributed to differences in operator technique and methodology.[22] Grubisa et al,[11] however, reported that the mean bond strength values obtained by three operators were not significantly different. The authors concluded that the self-etching primer (Transbond Plus) is less operator technique–sensitive than the conventional phosphoric acid etching. Fritz et al[23] stated that SBS can differ significantly depending on the method applied and suggested the need for a separate control for each study.

After debonding for the first 30 minutes (5, 15, and 30 minutes) a higher frequency of ARI scores of 3 was observed for the CM group. This indicated that more composite remained on the enamel surface, especially for the first 30 minutes, than when a self-etching primer was used.

Brackets are subject to either shear, tensile, or torsion forces, or a combination of these, during function. These forces are difficult to measure.[19] Clinically adequate bond strengths for metal orthodontic brackets to enamel should range from 6 to 8 MPa.[24] The SBS observed during the first 60 minutes were above these optimal values for both groups. In clinical practice, there is no consensus about the minimum time required before loading the bracket after bonding.[25] Suitable time intervals ranging from 5 minutes[26] to 30 minutes[27] and to 24 hours[28] were suggested. The results of the present study indicate that it is reliable to load the bracket 5 minutes after bonding using self-etching primer (Transbond Plus) with the light-cure adhesive (Transbond XT). However, as with any in vitro study, discretion should be exercised when attempting to extrapolate laboratory findings to the clinical setting.

In this study, an increase in SBS from 5 minutes to 24 hours was observed for both groups. Similar results were reported in other studies.[14,19,29] Rock and Abdullah[14] compared SBS with light-cured adhesive (Transbond XT with conventional phosphoric acid etching) at 15 minutes (7.71 MPa) and at 24 hours (18.17 MPa). They observed a significant difference between the two values. Chamda and Stein[29] presented a gradual increase in SBS from 0, 2, 5, 10, and 60 minutes to 24 hours (5.38 MPa, 6.50 MPa, 7.07 MPa, 7.08 MPa, 8.38 MPa, and 11.46 MPa, respectively) with light-cured adhesive (Transbond with conventional phosphoric acid etching). Likewise, Movahhed at al[19] observed an increase in SBS with light-cured adhesive (Transbond XT in combination with Transbond Plus self-etching primer) at 5 minutes (8.8 MPa) and at 15 minutes (11.0 MPa). The most reasonable explanation for the increased shear bond strength at 24 hours is that most of the free radicals are initially produced at the periphery of the resin where total light exposure is available, and the diffusion of these free radicals requires time to further polymerize the resin under the bracket base.[28,29]

CONCLUSIONS

- The results suggest no differences in SBS of orthodontic brackets between enamel treated with either the self-etching primer or the conventional method during the first 60 minutes (5, 15, 30, and 60 minutes).
- The new self-etching primer (Transbond Plus) can achieve adequate SBS levels during the first 60 minutes (5, 15, 30, and 60 minutes).
- It is reliable to load the bracket 5 minutes after bonding using self-etching primer (Transbond Plus) with the light-cure adhesive (Transbond XT).

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