

Microphotographic Assessment of Enamel Surface using Self-Etching Primer and Conventional Phosphoric Acid: An *In vitro* Study

Abstract

Introduction: Conventional acid-etching method irreversibly removes several microns of enamel surface and also involves many steps. Hence, a simplified technique that minimizes enamel loss, improves adhesion procedures, prevents saliva contamination, and saves chair time, thereby producing clinically useful bond strength, would be valuable. **Aim:** To assess and compare the bonding mechanism of a self-etching primer (SEP) to that of phosphoric acid on enamel of the human permanent teeth by a scanning electron microscope (SEM). **Materials and Methods:** Thirty freshly extracted premolars were randomly divided into two groups of fifteen teeth each – the control group I (phosphoric acid) and experimental group II (self-etching primer). Brackets were bonded using Transbond XT adhesive on the buccal surfaces of the teeth after etching and priming according to their respective protocols. The teeth were then sectioned and the samples were subjected to a protocol of demineralization cycles. After complete dissolution of dental tissues, the specimens were gold sputter coated and evaluated under SEM. **Results:** A characteristically uniform etch pattern was seen in the resin samples of the phosphoric acid/Transbond XT primer group, which revealed increased roughness and resin tags penetrating the demineralized enamel surface, whereas with Transbond Plus SEP, a regular resin tag distribution was observed which showed less magnitude when compared with the control group. **Conclusion:** From the study, it was concluded that Transbond Plus SEP produced an etch pattern which was more conservative than conventional phosphoric acid system.

Keywords: Phosphoric acid, scanning electron microscope, self-etching primer

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Introduction

The procedure for bonding brackets has become a challenging topic in orthodontics. The enamel-etching technique presented by Buonocore is commonly used when bonding brackets to the enamel surface.^[1,2] However, this conventional acid-etching method irreversibly removes several microns of enamel surface and also involves many steps, which makes the technique sensitive to saliva contamination and gingival irritation.^[3,4] It becomes important for the clinician to prevent enamel damage and maintain a sound tooth structure after debonding.^[2] Hence, a simplified technique that minimizes enamel loss, improves adhesion procedures, prevents saliva contamination, saves chair time, and prevents damage to gingival tissues producing a clinically useful bond strength would be advantageous.^[3]

To serve the aforesaid purposes, self-etching primers (SEPs) were introduced which

combined the conditioning and priming agents into a single acidic primer solution.^[4] Their etching pattern reported to be different from conventional etching, yet bond strength *in vitro* appears comparable or slightly lower.^[5]

In our study, we investigated, under laboratory conditions, the bonding mechanism of a SEP on enamel of human permanent teeth by a scanning electron microscope (SEM) and compared it to that of phosphoric acid.

Aim

The aim of this study is to assess and compare the bonding mechanism of a SEP to that of phosphoric acid on enamel of the human permanent teeth by SEM.

Materials and Methods

This *in vitro* study was conducted on 30 extracted human maxillary premolar teeth in the Department of Orthodontics

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and Dentofacial Orthopaedics, Guru Nanak Dev Dental College and Research Institute, Sunam. The premolars were obtained from a group of patients who underwent therapeutic extractions, before orthodontic therapy. Only morphologically well-defined teeth with no caries, fractures, or any restorations were included in the study. They were collected and stored in a solution of 0.1% (wt/vol) thymol.

The teeth were washed with distilled water, dried using chip blower, and then stabilized in the clamp before bonding. Using rubber cup mounted on a low-speed contra-angle handpiece and pumice slurry, the buccal surfaces of teeth were polished.

The teeth were then divided into two groups of 15 each corresponding to two protocols used for bonding in this study:

- (a) Group I (Control group) – The dried buccal surface of each tooth was etched with 37% phosphoric acid for 15 s, rinsed thoroughly with distilled water, and dried using chip blower. A thin coat of conventional Transbond XT primer was applied with a brush in a single stroke, and air was blown gently to remove excess primer. The adhesive (Transbond XT) was then applied to the metal bracket base. The metal brackets (Roth 0.022" slot, victory series, 3M Unitek), with the help of a bracket holder, were pressed gently at the center of the facial surface of the teeth to ensure uniformity in the bracket seating. Subsequently, using an explorer, the excess adhesive was removed from the margins of the bracket. The brackets to be bonded were light cured for 10 s on each proximal side with quartz tungsten halogen light cure unit (Dentsply)
- (b) Group II (Experimental group) – On the dried buccal surface of each tooth, a thin coat of SEP (Transbond Plus) was applied by continuously rubbing on the enamel surface for 3 s, which was then dried using compressed air to remove excess primer.

A thin layer of adhesive (Transbond XT) was then applied to the metal bracket base. The metal brackets (victory series, 3M Unitek) were pressed gently at the center of the buccal surfaces of the teeth. The samples were then stored in distilled water till further use. Crowns were sectioned longitudinally in a mesiodistal direction and then from the roots at the cemento-enamel junction using diamond disc. All samples were stored in distilled water at room temperature.

The bracket face of the sectioned specimens were embedded in resin and submitted to demineralization cycles which promoted complete dissolution of the dental structures. On an average, five consecutive cycles were carried out with each cycle comprising placement of samples in 10% chloridric acid solution for 5 hrs and 5% sodium hypochlorite solution for 1 hr. All baths and cycles were intercalated with 5 min distilled water rinse. After complete dissolution of dental tissues, the specimens were placed

on aluminum stubs followed by gold sputter coating of the bracket bases. The samples were then evaluated under SEM at two different magnifications of 1000× and 3500× and microphotographs were obtained [Figures 1-4]. The microphotographs were evaluated by three different

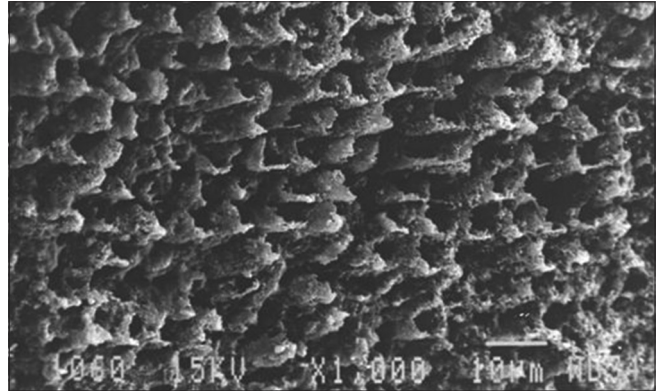


Figure 1: Scanning electron microscopic microphotograph at 1000× representative of resin sample of enamel etched with phosphoric acid (Group I)

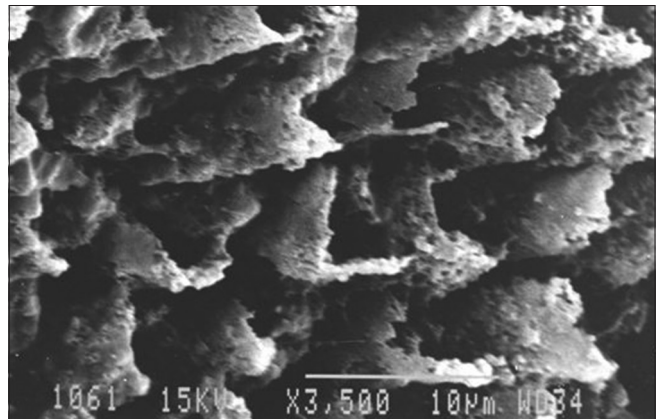


Figure 2: Scanning electron microscopic microphotograph at 3500× representative of resin sample of enamel etched with phosphoric acid (Group I)

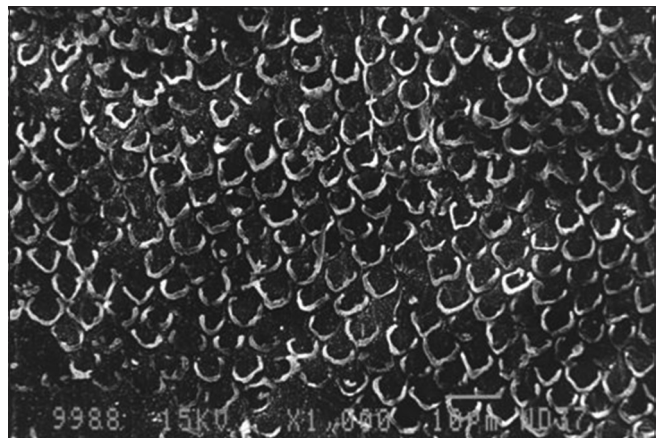


Figure 3: Scanning electron microscopic microphotograph at 1000× representative of resin sample of enamel etched with Transbond Plus self-etching primer (Group II)

examiners who gave scores according to the following adhesive penetration on enamel:^[2]

- 0 – without penetration
- 1 – shallow penetration
- 2 – deep penetration.

The values obtained from the scoring of microphotographs were tabulated [Tables 1-4] and analyzed using the Mann–Whitney–Wilcoxon or Wilcoxon rank-sum test to determine the statistical significance of the data ($P < 0.05$) [Tables 5 and 6].

Results

The results of our study confirmed a highly significant difference ($P < 0.001$) in the etch pattern of both groups [Tables 5 and 6] with SEP showing lower adhesive penetration, thus producing a more conservative etch pattern contributing to its lower bond strength. A characteristically uniform etch pattern was seen in the resin samples of the phosphoric acid/Transbond XT primer group, which

Table 1: Frequency distribution of scores of adhesive penetration of phosphoric acid and Transbond XT primer (Group I) on enamel evaluated from evaluated from microphotograph at 1000×

	n	Scores		
		0	1	2
Examiner - 1	15	0	2	13
Examiner - 2	15	0	0	15
Examiner - 3	15	0	3	12

Scoring - 0: Without penetration; 1: Shallow penetration; 2: Deep penetration

Table 2: Frequency distribution of scores of adhesive penetration of Transbond Plus self-etching primer (Group II) on enamel evaluated from microphotographs at 1000×

	n	Scores		
		0	1	2
Examiner - 1	15	0	12	3
Examiner - 2	15	4	11	0
Examiner - 3	15	3	10	2

Scoring - 0: Without penetration; 1: Shallow penetration; 2: Deep penetration

Table 3: Frequency distribution of scores of adhesive penetration of phosphoric acid and Transbond XT primer (Group I) on enamel evaluated from microphotographs at 3500×

	n	Scores		
		0	1	2
Examiner - 1	15	0	2	13
Examiner - 2	15	0	0	15
Examiner - 3	15	0	4	11

Scoring - 0: Without penetration; 1: Shallow penetration; 2: Deep penetration

revealed increased roughness and resin tags penetrating the demineralized enamel surface [Figures 1 and 2], whereas with Transbond Plus SEP, a regular resin tag distribution was observed which showed less magnitude when compared with the control group [Figures 3 and 4].

Discussion

The direct bonding method of orthodontic brackets has brought advancement in the clinical practice of

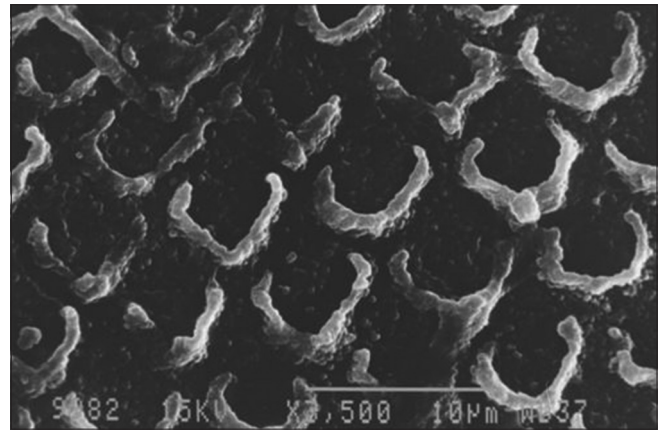


Figure 4: Scanning electron microscopic microphotograph at 3500× representative of resin sample of enamel etched with Transbond Plus self-etching primer (Group II)

Table 4: Frequency distribution of scores of adhesive penetration of Transbond Plus (Group II) on enamel evaluated from microphotographs at 3500×

	n	Scores		
		0	1	2
Examiner - 1	15	5	9	1
Examiner - 2	15	2	13	0
Examiner - 3	15	3	12	0

Scoring - 0: Without penetration; 1: Shallow penetration; 2: Deep penetration

Table 5: Comparison of score values of Group I and Group II at 1000×

	Examiner - 1	Examiner - 2	Examiner - 3
Mann-Whitney U-test	11.000	15.000	33.000
Wilcoxon W	131.000	135.000	153.000
Z	-4.605	-4.577	-3.648
P	<0.001	<0.001	<0.001

$P < 0.001$ - highly significant

Table 6: Comparison of score values of Group I and Group II at 3500×

	Examiner - 1	Examiner - 2	Examiner - 3
Mann-Whitney U-test	17.500	0.000	24.000
Wilcoxon W	137.500	120.000	144.000
Z	-4.286	-5.236	-4.107
P	<0.001	<0.001	<0.001

$P < 0.001$ - highly significant

orthodontics. However, still, a need for the improvement of the bonding procedure by minimizing enamel loss and saving time without jeopardizing the ability to maintain clinically useful bond strength is required.^[6]

The most conventional adhesive systems use three different agents: an etchant, a primer, and an adhesive resin. Acid conditioning of the enamel with 35%–37% phosphoric acid has been the most effective method for enhancement of the bonding of adhesive resin composite to enamel.

The use of phosphoric acid on enamel has been associated with an increase in the superficial roughness, rendering the enamel more retentive and producing higher bond strength.^[7] However, it is not desirable clinically because of the concerns that such bond strengths may be higher than what is required for a successful orthodontic bonding. Furthermore, phosphoric acid complicates the removal of residual adhesive on the enamel after debonding and can also lead to surface scratches and loss of sound enamel.^[8] Moreover, it has been demonstrated that the amount of adhesive remnant on enamel tends to be greater with high shear bond strength.^[4] Currently, there is an increasing preference for milder etching procedures.

SEPs are agents that combine conditioning and priming into one clinical step. They do not have to be rinsed off with water but just spread gently by applying a stream of air. As the monomers that cause etching are also responsible for bonding, the depth of the demineralized zone corresponds to the depth of penetration of the adhesive to be polymerized, thus causing sufficient penetration depth with improved quality of hybridization.

The method used in this study, i.e., using SEM and completely decalcified resin samples, is extremely simple and very useful to evaluate the resin tags and to assess the etching pattern of enamel surfaces. According to Ferrari *et al.*, low magnifications show the uniformity of the etch pattern of enamel and the density and real depth of the resin tags, whereas high magnifications demonstrate the morphological characteristics of the resin tags penetrating enamel.^[9] Perhaps, this is the most adequate technique to evaluate the bonding mechanism of SEPs on enamel.

As in this study, if resin replication rather than direct observations of enamel is evaluated, exact information can be obtained about the etching pattern and the adhesive penetration into enamel surface, regardless of the etching technique. This is true because with the self-etching primer, the ionic precipitate remains embedded in the resin after polymerization.^[5]

The results of our study confirmed a significantly high difference in the etch pattern of both the groups [Table 5 and 6] with self-etching primer showing lower adhesive penetration, thus producing a more conservative etch pattern contributing to their lower bond strength.

Successful clinical bonding is reported to be achieved at a shear bond strength as low as 6–8 Mpa;^[10] therefore, SEPs have been successfully used during bonding to reduce the etching of enamel and technique sensitivity.^[11,12] The efficacy of using a SEP, therefore, has been shown in various studies.^[11–16]

Clinical conditions during bonding procedure include a risk of contamination of the etched surface by saliva. It has been reported that when using phosphoric acid etchant, contamination with saliva causes a noticeable decrease in bond strength.^[17] SEPs are considered bicomponent hydrophilic adhesives and are known to be the least influenced by the presence of moisture. Recent investigations comparing bond strengths of SEPs with and without saliva contamination showed insignificant decrease in bond strength.^[18,19]

The effect of SEPs on the tooth surface after debonding is of importance as the enamel surface should have little possible residual adhesive on it after bracket removal since its removal will lead to enamel loss. It has been concluded that most surface loss occurs during enamel clean-up.

Recently, Vicente *et al.* and other authors reported that after using the conventional acid etching technique more adhesive remained on the enamel surface post debonding than after the use of a self etching primer.^[12,14,20]

Even if it has been maintained that bond failure at the bracket–adhesive interface or within the adhesive is safer than failure in the adhesive–enamel interface due to enamel cracking, phosphoric acid techniques are reported to be associated with a risk of enamel cracks during debonding. Thus, we conclude that phosphoric acid-etching produces more enamel fractures than SEP treatment, possibly a result of the reduced depth of demineralization of SEPs.^[10]

Therefore, from a clinical point of view, the use of self-etching primers can be desirable because they save chair time by reducing clinical steps and improve the adhesive procedures by reducing the risk of salivary contamination as well as provide adequate bond strength.^[21,22] Furthermore, the claim that self-etching primer produces a more conservative etch pattern than phosphoric acid, thereby minimizing the loss of enamel, was confirmed in this study.

Conclusion

From our study, it was concluded that a more conservative etch pattern and a lower adhesive penetration were produced by Transbond Plus SEP than when 37% phosphoric acid and a separate primer were used.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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