10.5005/jp-journals-10024-1137

ORIGINAL RESEARCH

Effects of a Self-Etching Primer and 37% Phosphoric Acid Etching on Enamel: A Scanning Electron Microscopic Study

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ABSTRACT

Objective: The purpose of this study was to compare the etching effects of a self-etching primer with 37% phosphoric acid on enamel by using a scanning electron microscope. Bond strength and the site of bond failure were also determined for brackets bonded using SEP and 37% phosphoric acid.

Materials and methods: A total of 60 maxillary premolar teeth were used for this study and they were divided into four groups. First two groups were used for studying the different types of etch patterns obtained and the next two groups were used to test the bond strength with the help of Universal testing machine. After debonding, the amount of residual adhesive was assessed according to adhesive remnant index using a stereomicroscope.

Results: The majority of etch patterns obtained in the 37% phosphoric acid group were type II, whereas in the SEP group, type IV pattern was more common. There was no statistically significant difference between mean bond strengths obtained with the SEP group and the phosphoric acid group. Use of SEP results in less amount of residual adhesive on tooth surface after debonding.

Conclusion: SEP produces more conservative etch pattern compared to 37% phosphoric acid. Use of SEP for bonding provides similar and clinically acceptable bond strength compared to use of 37% phosphoric acid etching technique and requires less clean-up procedures hence, reduces enamel loss.

Clinical significance: Use of 37% phosphoric acid for orthodontic bonding yields high bond strength but, causes enamel loss during both etching and debonding. SEPs not only provide adequate bond strength with a more conservative etch pattern but also enable easy debonding, thereby reducing the enamel damage.

Keywords: Etch pattern, Enamel, SEM, Self-etching primer.

How to cite this article: Nanjannawar LG, Nanjannawar GS. Effects of A Self-Etching Primer and 37% Phosphoric Acid Etching on Enamel: A Scanning Electron Microscopic Study. J Contemp Dent Pract 2012;13(3):280-284.

Source of support: Nil

Conflict of interest: None declared

INTRODUCTION

Despite the fact that acid etching technique is a widely used procedure in orthodontic field, there is a need to simplify the technique, while maintaining clinically useful bond strength and minimizing the amount of enamel loss. Thirty-seven percent phosphoric acid etching causes dissolution of interprismatic material in enamel, producing a roughened and porous layer that ranges in depth from 5 to 50 μm^2 which though increases the bond strength, may cause damage to enamel during debonding procedures.[1,2] New bonding systems include use of self-etching primers which have an advantage of a simplified procedure providing adequate etching and priming of enamel in one step only. It is claimed that SEPs not only provide adequate bond strength with a more conservative etch pattern but also enable easy debonding, there by reducing the enamel damage.[3-5]

The aim of this study was to compare the etching effects of a self-etching primer with 37% phosphoric acid on enamel by using a scanning electron microscope. Bond strength and the site of bond failure were also determined for brackets bonded using SEP and 37% phosphoric acid.

MATERIALS AND METHODS

In this study, 60 healthy maxillary premolars which were extracted for orthodontic purposes were used. These 60 specimens were divided into four groups of 15 each. First two groups were used for studying the different types of etch patterns obtained using SEM and the next two groups were used to test the bond strength with the help of universal testing machine. After debonding, the amount of residual adhesive was assessed according to adhesive remnant index using a stereomicroscope.

Determination of Etch Pattern

The teeth were placed on SEM stubs and desiccated in a warm-air oven at 37°C for 24 hours. Finally, the teeth were gold coated to a depth of 15 nm and examined under the SEM at 10 kV and × 1820 magnification.

According to Silverstone et al,[6] there are 5 types of etching patterns, and this was used as diagnostic criteria:

- Type 1: Preferential dissolution of the prism cores, resulting in a honey comb like appearance.
- Type II: Preferential dissolution of the prism peripheries, giving a cobblestone like appearance.
- Type III: A mixture of types I and II patterns.
- Type IV: Pitted enamel surfaces as well as structures that look like unfinished puzzles, maps or networks.
- Type V: Flat, smooth surfaces.

Mechanical Testing

The bond strength of these specimens was tested with the help of a universal testing machine (TIRA 2820S), with a crosshead speed of 1 mm/minute. The debonded brackets were then examined under the stereomicroscope at 30× magnification and the adhesive remaining on the bracket base was assessed using the adhesive remnant index.

Determination of Remaining Residual Adhesive after Debonding

The adhesive remnants were graded as per the adhesive remnant index developed by Artun and Bergland.[7]

RESULTS

The distribution of etch patterns between group I and II are represented in Table 1. Chi-square test of significance was used to assess the differences in the etch patterns and a statistically significant difference was noted. The p-value was 0.003 (<0.05). In group I, majority of the patterns (53.3%) obtained were type II, whereas in group II, type IV pattern dominated (40%). Figures 1 and 2 show a few etch patterns obtained with groups I and II respectively. Figure 3 shows distribution of shear bond strength (MPa) between groups III and IV. Mean and standard deviation were calculated as illustrated in Table 2. With a p-value of 0.993 (>0.05), Chi-square test revealed that the difference in the mean shear bond strength values obtained for groups III and IV was not statistically significant. Figure 4 shows distribution of adhesive remnant index scores between groups III and IV. Mean ARI scores are illustrated in Table 3. Chi-square test of significance with p-value of 0.019 (<0.05) revealed that differences in the mean ARI scores obtained for groups III and IV were statistically significant.

DISCUSSION

Introduction of acid etching technique by Buonocore,[1] has proven to be a land mark advancement in clinical orthodontic treatment and the literature is replete with related reports. Use of phosphoric acid on enamel has been associated with an increase in the superficial roughness, rendering the enamel more retentive and producing a higher bond strength.[1,2,8] However, there are concerns that such bonding levels may be higher than what is required for a successful orthodontic bonding and can cause more enamel loss during both etching and debonding.[9-11]

Enamel etching with phosphoric acid creates an etch pattern characterized by a deep and uniformly demineralized area and leads to greater depth of resin penetration.[12,13] It is observed that regardless of treatment time, etching with 37% phosphoric acid invariably results in irreversible damage of enamel surface.[14]

Hence, in recent years, there has been an increasing preference for milder etching procedures. These types of products have the advantage of a faster and simplified application technique and allow effective conditioning and priming of enamel and dentin in one step, without compromising on adequate bond strength.[15,16] SEPs demonstrate shallower etch pattern. This might be because of a poorer penetration of the acidic primer into the enamel porosities or the result of interference from calcium precipitates on the enamel surface, masking the etch pattern. This phenomenon, however, does not seem to affect the bond strength.[17-19]

Etch Pattern

The majority of etch patterns obtained in the 37% phosphoric acid group were type II. These results were in accordance with the results of similar studies.[11,20] The type II etch pattern causes maximum enamel loss, whereas the type I etch pattern leads to minimal enamel loss.[11,14] Type IV

Table 1: Distribution of etch patterns between groups I and II

Etch patterns	*Groups*	
	H_3PO_4	*SEP*
I	4	5
	26.7%	33.3%
II	8	0
	53.3%	0%
III	3	2
	20.0%	13.3%
IV	0	6
	0%	40.0%
V	0%	13.3%
	15	15
	15	15
Total	100.0%	100.0%

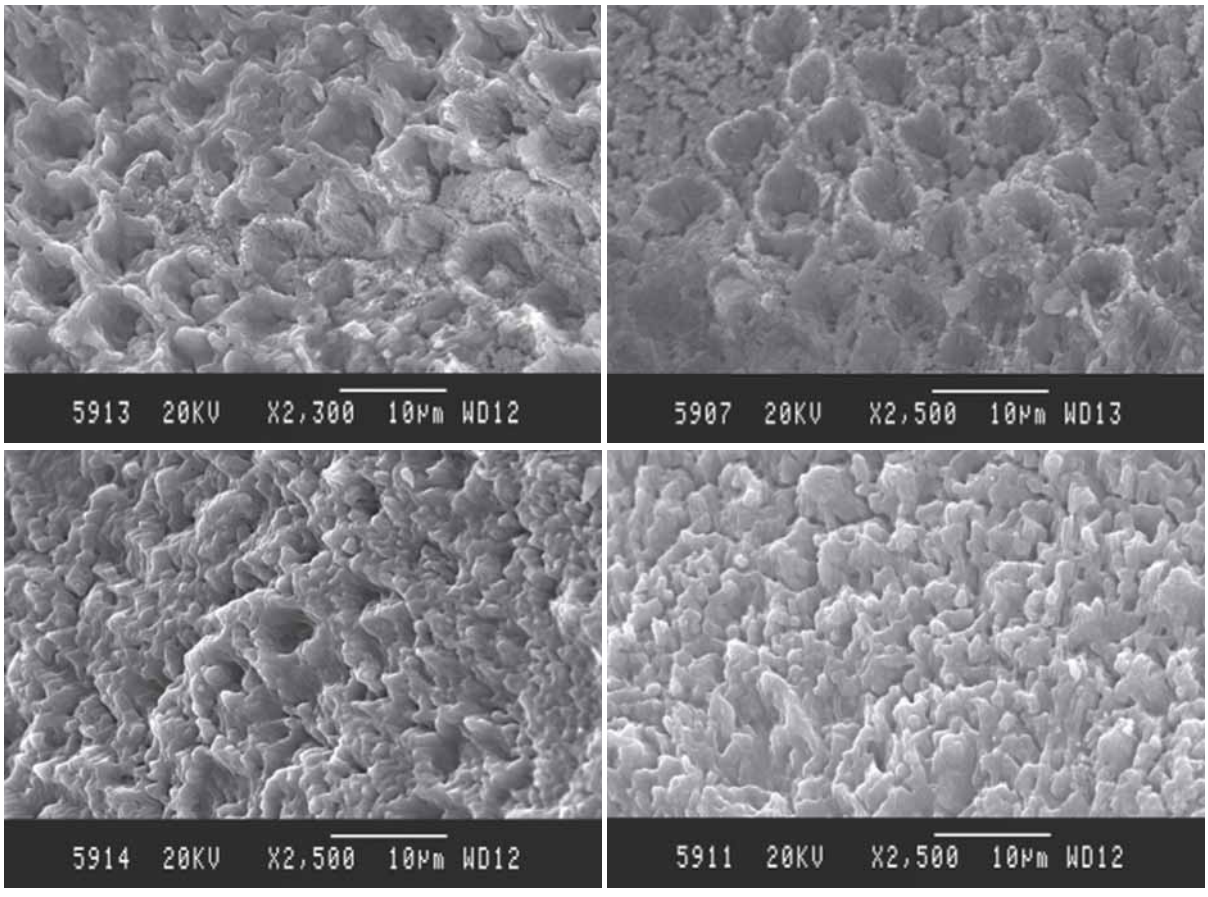

Fig. 1: Few etch patterns obtained with group I

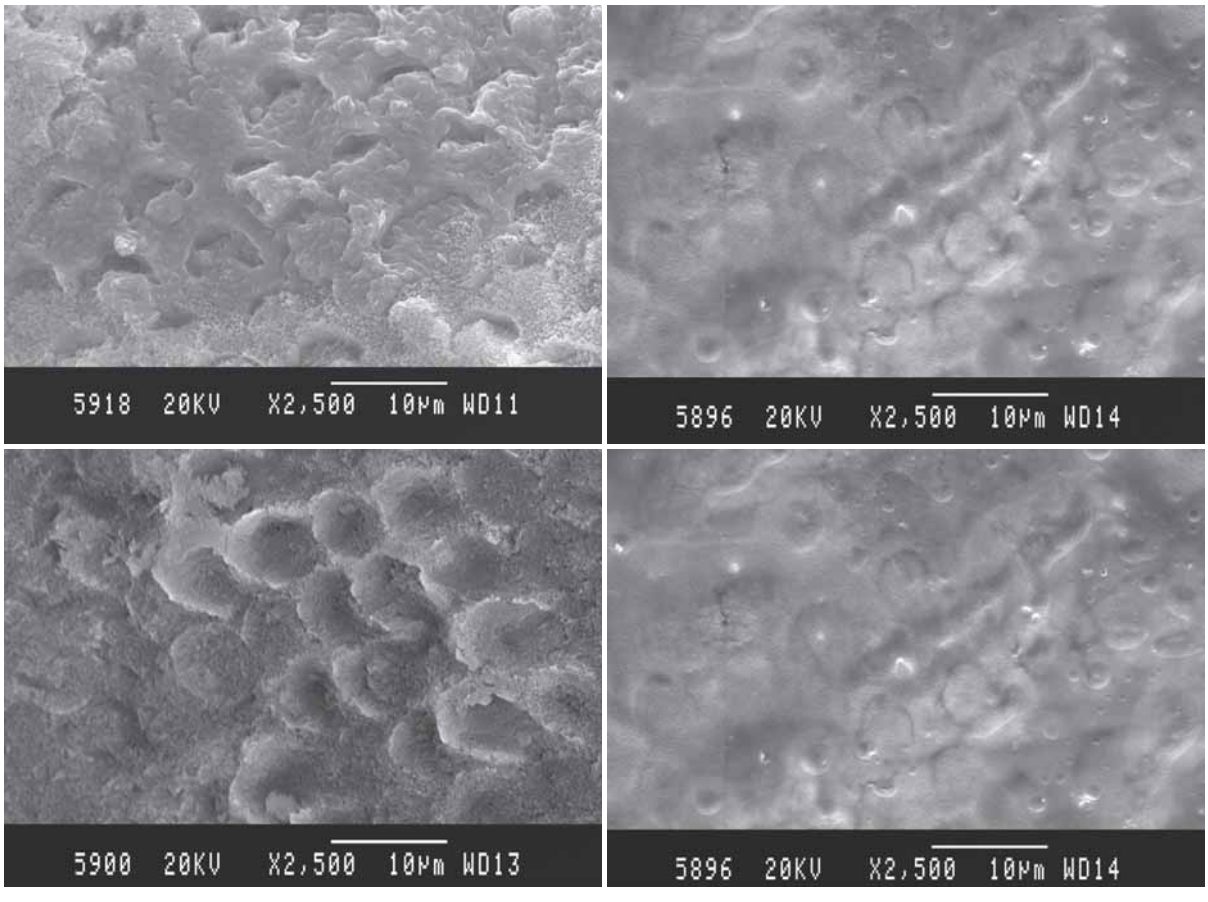

Fig. 2: Few etch patterns obtained with group II

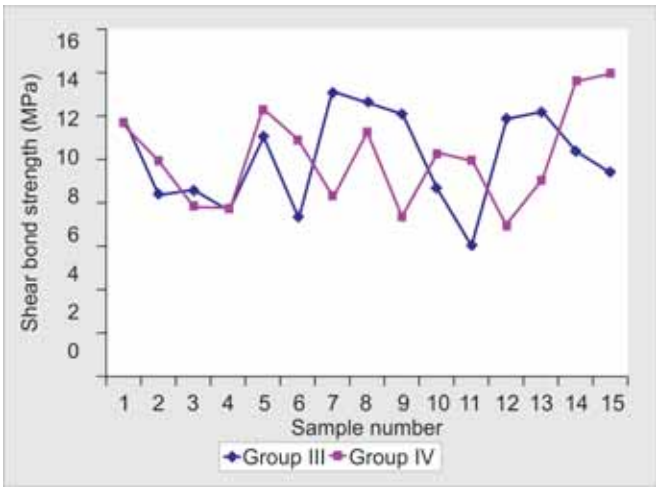

Fig. 3: Distribution of shear bond strength between groups III and IV

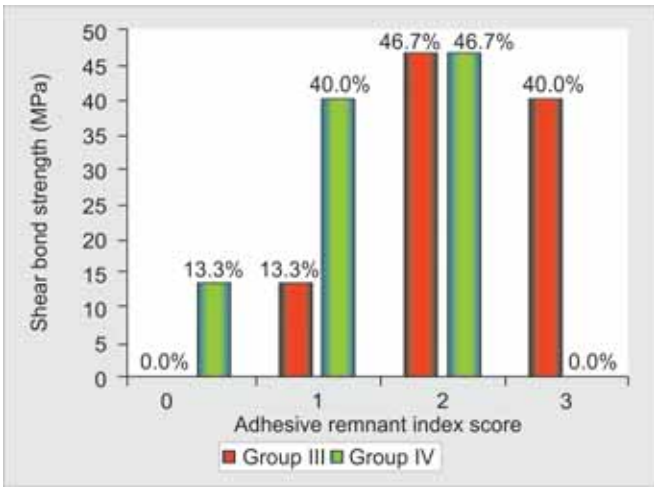

Fig. 4: Distribution of adhesive remnant index between groups III and IV

Table 2: Mean and standard deviation of bond strength values as calculated for groups III and IV

Groups	*N*	*Mean bond strength*	*Std. deviation*	*Minimum*	*Maximum*
III (37%H_3PO_4)	15	10.0600	2.20503	6.00	13.05
IV (SEP)	15	10.0527	2.22678	6.91	13.97

Table 3: Mean adhesive remnant index scores for groups III and IV

Groups	*N*	*Mean ARI scores*	*Std. deviation*	*Minimum*	*Maximum*
III (37%H_3PO_4)	15	2.27	0.704	1	3
IV (SEP)	15	1.33	0.724	0	2

pattern which was common in SEP group is a conservative etch pattern leading to minimal enamel loss.[3,4] Type V pattern includes flat smooth surfaces, which does not have much effect on enamel.

Bond Strength

Results of the present study concur with that of many other studies which have concluded similarly.[3,15,18,21-23] However, few studies found significantly lower, but clinically acceptable bond strengths when SEP was used.[24] Randomized clinical trials for 6 and 12 months evaluation of a self-etching primer *vs* phosphoric acid etching for orthodontic bonding found that the difference in the overall bond failure rate for the two systems was not statistically significant.[25,26] Some studies have shown that the bond strength obtained with use of SEPs for bonding is significantly low resulting in high rate of bond failure.[27,28] Saliva contamination significantly decreased the bond strength when conventional acid etching was used whereas no significant difference was observed with use of SEPs.[29,30]

ARI Scores

Results of the present study are in accordance with few other studies which found less adhesive left on teeth when SEP was used than when phosphoric acid etching was used. Whereas these results are contradictory to the results obtained in some other similar studies.[5,18]

As far as the limitations of the present study are concerned, since the *in vitro* testing can never simulate oral conditions precisely, the results need to be interpreted with care. Extensive clinical trials over extended periods are recommended to evaluate the feasibility of the materials tested.

CONCLUSION

Based on the recorded data and statistical analysis, the following conclusions can be drawn.

- SEP produced more conservative etch pattern compared to 37% phosphoric acid when observed under scanning electron microscope.
- Use of SEP for bonding orthodontic brackets showed similar and clinically acceptable bond strength compared to use of 37% phosphoric acid etching technique.
- Use of 37% phosphoric acid etching for bonding, results in more amount of residual adhesive on tooth surface, whereas use of SEP results in less amount of residual adhesive on tooth surface which requires less clean-up procedures hence, reduces enamel loss.

CLINICAL SIGNIFICANCE

Use of phosphoric acid on enamel has been associated with an increase in the superficial roughness, rendering the enamel more retentive and producing a higher bond strength. However, this may not be desirable clinically because there are concerns that such bonding levels may be higher than what is required for a successful orthodontic bonding and can cause more enamel loss during both etching and debonding. SEPs not only provide adequate bond strength with a more conservative etch pattern but also enable easy debonding, requiring less clean-up procedures, thereby reducing the enamel damage.

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