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A comparison of orthodontic bracket shear bond strength on enamel deproteinized by 5.25% sodium hypochlorite using total etch and self-etch primer

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Abstract. The shear bond strength (SBS) can be increased by removing protein pellicles from the enamel surface by deproteinization using 5.25% sodium hypochlorite (NaOCl). The SBS of a self-etch primer is lower than that of a total etch primer; nonetheless, it prevents white spot lesions. This study aimed to assess the SBS of the Anyetch (AE) total etch primer and FL-Bond II Shofu (FL) self-etch primer after enamel deproteinization using 5.25% NaOCl. Forty eight human maxillary first premolars were extracted, cleaned, and divided into four groups. In group A, brackets were bonded to the enamel without deproteinization before etching (A1: 10 teeth using total etch primer (AE); A2: 10 teeth using self-etch primer (FL)). In group B, brackets were bonded to the enamel after deproteinization with 5.25% NaOCl before etching (B1: 10 teeth using total etch primer (AE); B2: 10 teeth using self-etch primer (FL)). Brackets were bonded using Transbond XT, stored in artificial saliva for 24 h at 37°C, mounted on acrylic cylinders, and debonded using a Shimadzu AG-5000 universal testing machine. There were no significant differences in SBS between the total etch (AE) groups ($p > 0.05$) and between the self-etch (FL) groups ($p > 0.05$). There were significant differences in SBS between groups A and B. The mean SBS for groups A1, A2, B1, and B2 was 12.91±3.99, 4.46±2.47, 13.06±3.66, and 3.62±2.36 MPa, respectively. Deproteinization using NaOCl did not affect the SBS of the total etch primer (AE) group; it reduced the SBS of the self-etch primer (FL) group, but not with a statistically significant difference.

1. Introduction

Fixed orthodontic appliances used in orthodontic treatment should have good bond strength. An orthodontist must use the correct method to bond an orthodontic appliance so as to preserve the enamel and to save chair time, compared to conventional systems. Self-etch primers were developed to improve the bonding procedure of orthodontic brackets. Such primers consist of an acid primer liquid that combines etching and priming in one step. The advantages of a self-etch primer are that it preserves enamel loss, resolves saliva contamination, and reduces the chair time [1,2]. Some fluoride-releasing self-etch primers may also prevent white spot lesions underneath and around the bracket [3,4]. On the other hand, several studies have shown that a self-etch primer has lower shear bond strength (SBS) than a total etch primer [5-7].

However, the main issue faced by orthodontists is the retention of the orthodontic appliance, that is, bond failure during orthodontic treatment. This issue lengthens the treatment time, and it may also cause enamel demineralization [8,9]. The orthodontic bond strength can be increased by removing organic substances from the enamel surface before etching by using 5.25% sodium hypochlorite (NaOCl) for deproteinization. Enamel deproteinization using 5.25% NaOCl was introduced by Espinosa *et al*. [10]. This method resulted in a better etch pattern on the enamel surface and increased the bond strength of most adhesives significantly [10].

2. Materials and Methods

Forty-eight extracted human maxillary first premolars for orthodontic treatment were cleaned in an ultrasonic cleaner, mounted individually in acrylic cylinders, and stored in sodium chloride at room temperature. Teeth were selected only if they had intact buccal enamel without fractures or cracks on the buccal surface; had no dental pathologi, malformation, staining, restoration, or erosion; and had never been bonder before or been pretreated by chemical agents (e.g. NaOCl, alcohol, H_2O_2). The teeth were randomly divided into four groups of 12 each. In group A, brackets were bonded to the enamel without deproteinization before etching (A1: 12 teeth using total etch primer (AE; Anyetch); A2: 12 teeth using self-etch primer (FL; FL-Bond II, Shofu). In group B, teeth were etched and bonded with brackets after enamel deproteinization using 5.25% NaOCl (B1: 12 teeth using AE total etch; B2: 12 teeth using FL self- etch primer). The buccal surface of all specimens was cleaned using non-fluoridated pumice and a nylon brush for 10 s, following which it was rinsed thoroughly. In group A1, which served as the control group, the buccal surface was etched with 37% phosphoric acid for 15 s, rinsed thoroughly, and dried, following which a bracket was bonded. In group A2, self-etch primer was applied to the enamel by using a microbrush for 10 s and dried for 1–2 s, followed by bonding agent application and curing using an LED lightcure for 5 s; finally, the bracket was bonded. In groups B1 and B2, the same procedure was used as in groups A1 and A2, except that enamel deproteinization with 5.25% NaOCl was conducted before etching by using a cotton pellet for 60 s, rinsing, and drying.

In this study, orthodontic premolar MBT metal brackets (Mini Diamond ORMCO) were used. The surface area of each bracket mesh was measured and recorded using a Digimatic Caliper (Mutitoyo). All brackets were bonded on to the premolars using Transbond XT. Excess composite around the bracket was removed using a sharp explorer, following which the bracket was lightcured for 40 s (10 s on each side) and stored in artificial saliva for 24 h at 37 °C. The samples were then debonded using a Shimadzu AG-5000 universal testing machine at a crosshead speed of 0.5 mm/min with a load of 50 kg. The results on the universal testing machine were recorded in units of kilogram force (kgF) and then converted to units of MPa by dividing the result by the surface area of the mesh bracket and multiplying with 9.8 MPa. All bracket mesh and enamel surfaces of the specimen were evaluated using a stereomicroscope (Nikon SMZ800) with 2x magnification to locate adhesive failures and to determine the Adhesive Remnant Index (ARI) score. Statistical Package for the Social Science 17.0 (SPSS 17.0) software was used to analyze the data.

3. Results and Discussion

3.1 Results

The results indicated that group B1 (total etch primer with 5.25% NaOCl enamel deproteinization) showed the highest SBS. Group B2 (self-etch primer with 5.25% NaOCl enamel deproteinization) showed the lowest SBS. Table 1 shows the SBS values and descriptive statistics of these results. The independent-samples ttest was used for statistical analysis, and it revealed statistically significant differences ($p < 0.05$) in SBS between the groups (Table 2).

There was no significant difference in the SBS in the total etch primer group between with and without enamel deproteinization, although the SBS was enhanced. There was no significant difference in the SBS in the self-etch primer group between with and without enamel deproteinization, although the SBS decreased slightly. Table 3 shows the adhesive failure modes of all groups. There was no significant difference between the Anyetch group ($p = 0.518$) and the FL-Bond II group ($p = 0.249$).

Table 1. Descriptive statistics continuous measures (MPa)

Group	n	Mean	Standard deviation	Minimum	Maximum
Anyetch without NaOCl (A1)	12	12.91	3.99	11.05	14.78
Anyetch with NaOCl (B1)	12	13.06	3.66	11.20	14.92
FL-Bond II without NaOCl (A2)	12	4.46	2.47	2.60	6.33
FL-Bond II with NaOCl (B2)	12	3.62	2.36	1.75	5.50

Table 2. Independent-samples t test of shear bond strength between various materials

Groups	Shear bond strength (MPa)		p-value
	Mean	Standard Deviation	
Anyetch without NaOCl (A1)	12.91	3.99	0.925
Anyetch with NaOCl (B1)	13.06	3.66	
FL-Bond II without NaOCl (A2)	4.46	2.47	0.399
FL-Bond II with NaOCl (B2)	3.62	2.36	
Anyetch without NaOCl (A1)	12.91	3.99	0.000
FL-Bond II without NaOCl (A2)	4.46	2.47	
Anyetch with NaOCl (B1)	13.06	3.66	0.000
FL-Bond II with NaOCl (B2)	3.62	2.36	

Table 3. Frequency distributions of ARI Scores of evaluated groups

Group	ARI Score*				
	0	1	2	3	p-value
Anyetch without NaOCl (A1)	3	7	2	0	0.518
Anyetch with NaOCl (B1)	2	4	6	0	
FL-Bond II without NaOCl (A2)	12	0	0	0	0.249
FL-Bond II with NaOCl (B2)	7	5	0	0	

* 0: no adhesive remained on the tooth; 1: <50% adhesive remained on the tooth; 2: >50% adhesive remained on the tooth; 3: all adhesive remained on the tooth.

3.2 Discussion

Since Buonocore introduced acid etching by applying 85% phosphoric acid to enamel to increase the adhesion of acrylic resin in 1955, acid etch has been used widely. When the acid etch is applied, enamel crystals inside the enamel prism dissolve and leave a roughened surface that provide adequate micromechanical retention. The depth of the micropores formed on the enamel by acid etching is 5–50 μm [11,12]. Recently, self-etch primers are being used commonly because they can release fluoride to prevent the formation of white spot lesions and also speed up the bonding procedure and chair time [13]. Self-etch adhesive systems are advantageous because they are simpler and time-efficient as they require fewer steps. Some studies have shown that the bond strength of self-etch primers is lower compared to that of the conventional total etch [14]. This might be caused by the shallower penetration of the etch, resulting in shorter adhesive tags on the enamel surface, especially in the case of a mild etch adhesive (pH 2–2.2) [4,15]. Many self-etch primers contain water that might interfere with the polymerization of the resin [15].

Previous studies have shown an increase in the SBS if the enamel surface was deproteinized by 5.25% NaOCl. Espinosa *et al.* [10] showed that the application of 5.25% NaOCl for 1 min on the enamel before etching increased the etching pattern quality, because it eliminated the organic content on the enamel surface. This study evaluated two acid etching systems for bonding orthodontic brackets: Anyetch total etch primer and FL-Bond II self-etch primer. These two etch systems were compared with and without the application of 5.25% NaOCl enamel deproteinization for 1 min before the bonding procedure. The main objective was to determine whether 5.25% NaOCl enamel deproteinization increased the SBS in both etching groups. Rastelli et al. [16] considered 6–8 MPa as an adequate SBS for clinical use. In this study, only groups A1 and B1 (Anyetch group) afforded higher SBS, whereas groups A2 and B2 (FL-Bond II group) had SBS lower than the minimum value. The mean SBS for the Anyetch group without (A1) and with (A2) NaOCl was 12.91 ± 3.99 and 4.46 ± 2.47 MPa, respectively, and that for the FL-Bond II group without (B1) and with (B2) NaOCl was 13.06 ± 3.66 and 3.62 ± 2.36 MPa, respectively. These results are similar to those obtained by Scougall-Vilchis *et al*. [4], in which the shear bond strength of FL-Bond II without enamel pretreatment by NaOCl was tested.

The ARI score indicated that bond failure for all brackets bonded using the self-etch primer without 5.25% NaOCl occurred at the enamel-adhesive interface, whereas brackets bonded with 5.25% NaOCl showed less failure at this interface. The ARI score of the self-etch primer group was similar to that of the total etch primer group. This showed that after deproteinization, more adhesive remained on the enamel. These results are similar to those obtained by Justus *et al*. [17]. The present findings indicate that by conditioning the enamel surface using 5.25% NaOCl before etching, the SBS of the total etch primer group increased by 0.15 MPa (nonsignificant increase), whereas that of the self-etch primer group decreased by 0.84 MPa (nonsignificant decrease). The ARI score indicated increased adhesion of the enamel surface after deproteinization in both groups, probably because of the better etch pattern. The nonsignificant effect of NaOCl on the SBS might also be attributable to the storage of the specimens after extraction, before bracket bonding. The specimens were stored in NaCl solution, which may remove the organic elements on the enamel surface [17].

4. Conclusion
The SBS of the FL-Bond II group without and with NaOCl deproteinization is lower than that of the Anyetch group. Enamel deproteinization using 5.25% NaOCl did not result in any increase in the SBS. However, NaOCl enamel deproteinization increased the adhesion to the enamel.

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