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RESEARCH ARTICLE

Evaluation of the Effect of Enamel Deproteinization Combined with a Self-etching Primer on the Adhesion of Orthodontic Brackets: An *In Vitro* Study

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Abstract:

Aim:

The study aimed to evaluate enamel deproteinization with sodium hypochlorite in the enamel conditioning using a self-etching primer for adhesion in orthodontic brackets.

Background:

The bonding in orthodontics plays a major role in the success of the treatment. The self-etching primers reduce the chair time and diminish the risk of saliva contamination.

Methods:

The sample comprised 80 bovines' incisors, divided into 4 groups according to the deproteinization process and adhesive system used: G1: enamel deproteinization + Transbond Plus self-etching primer + Transbond XT adhesive; G2: enamel deproteinization + 37% phosphoric acid + conventional primer + and Transbond XT adhesive; G3: Transbond Plus self-etching primer + Transbond XT adhesive; and G4: 37% phosphoric acid + conventional primer + Transbond XT adhesive. EMIC[®] DL 500 Universal Testing Machine was used for testing the shear bond strength of the samples.

Results:

Brackets bonded with self-etching primer showed greater adhesion force. The enamel deproteinization did not improve the bonding strength, regardless of the primer used.

Conclusion:

The deproteinization process does not improve the result of the adhesive bonding when using a self-etching primer *in vitro*.

Keywords: Acid etching, Dental bonding, Dental enamel, Orthodontics, Orthodontic brackets, Sodium hypochlorite.

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1. INTRODUCTION

In orthodontic treatment, the evolution of the materials used to bond orthodontic brackets and accessories to the dental enamel surface is extremely important. Detachment of orthodontic accessories can lead to patient discomfort, in addition to delaying the treatment time [1, 2]. In addition, orthodontic accessories support many different forces in diffe-

rent directions, and the adhesion must resist those forces so the treatment can be effective [2, 3].

The retention properties of dental enamel have been studied for many years [4 - 7]. Buonocore, in 1955, introduced the use of phosphoric acid [8], while Nishida, in 1993, demonstrated the first bonding system that combined an etchant conditioner and a primer resin agent. Both could be used in only one step [9]. The latter simplified the use of adhesive systems and allowed the enamel beneath the brackets to be preserved after their removal [10]. The self-etching

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primer is widely used in different dentistry areas as it is a simple procedure that reduces steps and clinical time [11]. Other advantages of self-etching primers are the preservation of enamel loss and the decrease in saliva contamination [12]. Studies show that the shear bonding resistance of the self-etching primer exhibits no significant difference from the conventional acid-etch technique [13, 14]. Even with long-term success rates of composite restorations using only self-etching primers, dentists may choose to use the traditional 37% phosphoric acid to increase the adhesive force [15, 16]. Etching is the first step for bracket adhesion. Enamel etching in orthodontics consists of applying 37% phosphoric acid before using the adhesive. It is known that the acid can not remove the organic material on the enamel surface, even after the polishing [17]. The excess of oral proteins on the enamel surface may be the cause of bonding failure in many cases [18, 19]. In those cases, some studies showed that using a deproteinizing agent may improve the adhesion of the enamel [20 - 22].

Several products have been tested as deproteinization agents, especially 5% sodium hypochlorite (NaOCl) and a 10% papain gel synthesized from the papaya fruit. Both have antibacterial and anti-inflammatory activity and can remove excess protein from the enamel's surface [23]. In 2008, Espinosa *et al.* [17] suggested using 5% sodium hypochlorite (NaOCl) as a deproteinization agent before using 37% phosphoric acid. It has been used in endodontic procedures as an irrigating solution. It exhibits some antibacterial effect without damaging the enamel or other healthy tissues. Other authors have endorsed this deproteinization as beneficial before the acid enamel preparation [19, 22, 24].

Using 5% sodium hypochlorite before the use of 37% phosphoric acid significantly improves the etched area and the acid pattern [14, 25, 26]. But the use of sodium hypochlorite before the self-etching primer still requires more information. Therefore, the objective of this study was to evaluate the effect of enamel deproteinization associated with the self-etching primer on the adhesion of orthodontic brackets.

2. MATERIALS AND METHODS

The sample size calculation was based on an alpha significance level of $\alpha=5\%$ (type I error) and $\beta=20\%$ (type II error), with a standard deviation of 1.2 to detect the minimum difference of 1.1Mpa for the shear resistance [27, 28]. The results showed the need for 20 specimens in each group.

The sample comprised 80 bovine incisors, which were cleaned and free of cracks, decays, white spots, hypoplastic areas, and enamel irregularities, followed by disinfection and storage in 0.1% thymol at room temperature.

All incisors had their buccal surfaces sectioned in enamel/dentin blocks of 6x6 mm with a precision cutter (Isomet 1000, Buehler, Lake Bluff, EUA), and included in PVC tubes (2 cm diameter and 2.5 cm high) with chemically activated acrylic resin (VipiFlas – DentalVip, Pirassununga, Brazil), with the enamel surface aligned with the resin surface.

The manufactured blocks were finished and polished using #1200 silicon carbide sandpaper, followed by #600 metallographic polirix (Aropol-2V, São Paulo, Brazil). In the

sequence, felts (TOP, RAM, and SUPRS from Arotec, Cotia, Brazil) were used with diamond paste (1, ½, and ¼ μ). The samples were allocated in the ultrasonic cube for cleaning between each polishing step. Finally, teeth were prepared, and the samples were randomly divided into 4 experimental groups (n=20), as follows:

Group 1 (G1): Enamel deproteinization with 5% sodium hypochlorite + self-etching primer (SEP) Transbond Plus + Transbond XP resin (3M Unitek, Monrovia, USA);

Group 2 (G2): Enamel deproteinization with 5% sodium hypochlorite + 37% phosphoric acid + conventional primer + Transbond XP resin (3M Unitek, Monrovia, USA);

Group 3 (G3): Self-etching primer (SEP) Transbond Plus + Transbond XP resin (3M Unitek, Monrovia, USA);

Group 4 (G4): 37% phosphoric acid + conventional primer + Transbond XP resin (3M Unitek, Monrovia, USA).

Prior to the bonding, all samples were cleaned with rubber cup prophylaxis (Microdont, São Paulo, Brazil) and pumice paste (SS White, Rio de Janeiro, Brazil). The surface was washed with distilled water, air sprayed for 10 seconds, and dried with paper tissue.

Mandibular incisors metal brackets were used. The bonding procedures were according to each group protocol, with the adhesives applied according to the manufacturer's specifications.

In groups G1 and G2, the deproteinization of the enamel surface was achieved with the application of 5% sodium hypochlorite (NaOCl) (Iodontosul, Porto Alegre, Brazil) using cotton swabs (Higie-plus Cottonbaby, São José, Brazil) for 60 seconds, followed by water spray washing for 15 seconds. For groups G2 and G4, conventional etching was performed with 37% phosphoric acid on the enamel for 15 seconds, followed by water spray and air drying. After the acid conditioning, the Transbond Plus primer (3M Unitek, Monrovia, USA), followed by the Transbond XT orthodontic resin in the base of each bracket, was applied. After that, the brackets were placed in position, the excess resin was removed, and polymerization (Schuster Emitter C, Santa Catarina, Brazil) was carried out for 10 seconds on the mesial surface and 10 seconds on the distal surface of each bracket, as specified by the manufacturer.

For the brackets bonding in groups G1 and G3, the self-etching primer (SEP) Transbond Plus (3M Unitek, Monrovia, USA) was applied by friction on the enamel surface for 5 seconds, followed by the application of the Transbond XT orthodontic resin in the base of each bracket set in position; the excess resin was removed, and polymerization was carried out for 10 seconds on the mesial surface and 10 seconds on the distal surface of each bracket, as specified by the manufacturer.

The samples were submerged in remineralizing artificial saliva and stored in a stove at 36,5 Celsius for 24 hours, and then subjected to the shear test, conducted using a Universal Testing Machine (EMIC® DL 500, Emic Equipamentos e Sistemas de Ensaio Ltda., São José dos Pinhais, Brazil) at a constant speed of 1mm/min. A 500N cell charge was connected to a computer so that the shear forces applied would be recorded in Newton by the TESC Emic software (InterMetric,

Mogi das Cruzes, Brazil). The Newton forces were then converted in Mpa by the $Mpa = N/mm^2$ formula.

2.1. Statistical Analysis

The normality of the data was checked with the Shapiro-Wilk test. The shear force between the groups was compared with the one-way ANOVA and Tukey test when necessary. The data were analyzed with Statistica for Windows (Statsoft, Tulsa, USA), considering a significance level of 5.

3. RESULTS

A statistically significant difference in the shear force was found between the evaluated groups (Table 1). The groups that used the self-etching primer showed greater shear force. The enamel deproteinization with sodium hypochlorite did not improve the shear force, regardless of the primer used. Group 1 has A and C superscript letters, while group 3 has A superscripted, and Group 4 has B and C. The groups with similar letters present no statistical differences between them, which means that Group 1 (AC) has no significant difference with Group 3 (which has A superscripted) and with Group 4 (which has AB superscripts d).

Table 1. Results of the intergroup comparison of the shear force (One-way ANOVA and Tukey test).

	Group 1	Group 2	Group 3	Group 4	P
	Mean (DP)	Mean (DP)	Mean (DP)	Mean (DP)	
Shear force (Mpa)	21.98 (3.52) AC	17,30 (4.53) B	24.23 (4.71) A	19.32 (4,10) BC	0.000*

Note: *statistically significant for $p < 0,05$.
*different letters indicate the presence of a statistically significant difference between the groups

4. DISCUSSION

The present study evaluated the use of 5% sodium hypochlorite for enamel deproteinization before using a self-etching primer. Sodium hypochlorite is an irrigating solution widely used in endodontics. It is known for its organic elements dissolving properties [24]. Based on these properties, it could be assumed that applying sodium hypochlorite previous to enamel etching will eliminate organic components from the enamel surface, allowing the acid to penetrate more efficiently into the enamel [29]. It is speculated that this improvement in the acid efficiency allows the bonding resin to have better adhesion and improves the resistance to the shear bond strength [20].

Most studies have compared the use of sodium hypochlorite with the traditional bonding system (37% phosphoric acid + conventional primer) but have not used the self-etching primer [14, 30 - 32]. The self-etching primer turns a 2-step preparation into a 1-step preparation, which saves chair time for the orthodontist and decreases the amount of residual adhesive on the enamel surface after the removal of the brackets [14, 33]. In our study, the groups that used the self-etching primer showed greater shear force (Table 1). Because of this faster method, which is 24-26 seconds faster than the conventional method (37% phosphoric acid + primer) per bracket, the self-etching primer is being used by more than

40% of American orthodontists [34]. However, the same study shows that, in this method, the pumice prophylaxis is necessary for a good result, so the time spent with the prophylaxis would make the total amount equal in both the methods [34]. A significant difference was observed in the shear force between the two bonding systems used, showing better results for the self-etching system when compared to the conventional method. This finding contradicts some studies that evidenced better results than traditional acid conditioning [26, 35]. These results also contradicted some studies, which showed that both bonding systems presented similar results [32, 36].

In the present study, enamel deproteinization did not influence the shear force strength of the orthodontic brackets (Table 1). Some authors found different results. Sharma *et al.* [37] found a 94.47% improvement in the adhesion when applying 5% sodium hypochlorite for 1 minute previously to the enamel etching. This difference concerning our results is probably because they used human teeth with fluorosis [38]. Espinosa *et al.* [17] demonstrated the use of 5% sodium hypochlorite for 1 minute before the appliance; the etching pattern improved the enamel retentive surface by 50%, which is an excellent improvement for shear bonding strength. On the other hand, other researchers have found this improvement to not be enough to make a difference in clinical use [12, 39].

On comparing 5% sodium hypochlorite as a deproteinization method before the selected etching system, this study demonstrated that deproteinization did not induce a statistically significant improvement in the shear bond strength, independently of the chosen bonding system. The self-etching system improved the shear bonding strength when compared to the traditional method, and this same result can be found in other studies [12, 19, 25].

The shear resistance was considered adequate for clinical use, even though sodium hypochlorite did not impact the shear force. This finding contradicts some laboratory studies that evidenced sodium hypochlorite as a promoter of the adhesion force [22, 26].

The present study indicated that 5% sodium hypochlorite did not alter the brackets' bonding shear resistance, whether it was used with the conventional 37% phosphoric acid and primer or with the self-etching primer. Other studies evidenced the same limitations for sodium hypochlorite, not showing enough positive evidence for its use [12, 19].

New clinical controlled studies should be developed to aim for unanimity and a better understanding between those studies. Also, the same method used in this study should be used in an *in vivo* analysis to test if the oral environment would show different results.

CONCLUSION

The orthodontic brackets bonded with the self-etching primer showed a greater adhesion force. The enamel deproteinization with 5% sodium hypochlorite did not improve the adhesion force in the brackets, regardless of the primer used.

LIST OF ABBREVIATIONS

NaOCl	=	Sodium Hypochlorite
SEP	=	Self-etching Primer

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No animals/humans were used for studies that are the basis of this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The datasets used to support the findings of this study may be released upon application to the Uningá Institutional Review Board, which can be contacted at tifialho@hotmail.com.

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None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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