Comparison of Shear Bond Strength of Composite Restorations to Intact Enamel of Primary Incisors When Using Different Conditioners and Adhesive Systems

Original Article

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Abstract

Introdouction:
Esthetic demands of patients have led to the introduction of tooth-colored restorations wherecomposite resins are bonded to the enamel using acid etch techniques. Total etch adhesion systems are still considered as the gold standard among bonding systems. However, clinicians have a tendency to use adhesive systems with simpler application procedures. The aim of the present study is to compare the shearbond strength of composite restorations to intact enamel of primary incisors when using different conditioners and adhesive systems.

Materials and methods:
This experimental study was conducted in Shiraz University of Medical Sciences. 53 teeth were collected and classified into five groups based on the bonding procedure. After composite buildup, specimens were placed in a universal testing machine with a cross-head speed of 1mm/min. Inter-group comparison of the shearbond strength to enamel was analyzed employing one-way-ANOVA and Tukey's post-hoc test. Data were statistically analyzed using SPSS (Version 17, Chicago, IL, USA).

Results:
The highest shearbond strength was found in the second (37% phosphoric acid etching + Margin Bond adhesive system) and fifth groups (37% phosphoric acid etch + Tokuyama Bond Force adhesive system), and the lowest bond strength was found in the third group (Tokuyama Bond Force adhesive system alone) ($p = 0.00$).

Conclusion:
Based on the results of the present study, surface pre-treatment with 37% phosphoric acidalong with self-etching adhesive system resulted in increased shearbond strength in vitro. This method can be further studied in clinical settings.

Key words:
•Shear Strength •Dental Enamel • Incisor

Introduction

Esthetic demands of patients have led to the introduction of tooth-colored restorative materials, where in composite resins are bonded to the enamel using acid etch technique. However, dentin adhesion is not as predictable as enamel bonding.[1]The adhesion mechanism is based on the penetration of resin molecules into the enamel and dentin. The tooth-composite adhesion strength is an important factor in the clinical durability of composite restorations.[2] Proper enamel adhesion has been achieved by means of phosphoric acid (PA) etching.[3] However, dentin bonding is much more reliable than enamel bonding because ofits tubular structure, higher organic content, and outward fluid flow.[4] Various bonding systems have been introduced in order to achieve a reliable bond to the tooth structure,and these are based on two main methods: the total etch technique and self-etching system. The total etch system is based on the removal of the smear layer and formation of a collagen fibril layer(hybrid layer)using acid conditioner{1.1 [EN] Please check the change}.[5] The collagen layer formed is sensitive to desiccation; therefore, necessitating humidification of the tooth surface.[6] The self-etching system is subdivided into two groups: two- and one-step self-etching. In the one-step self-etch approach, the conditioner, primer and adhesive are combined andno post-conditioning rinse is required.[7] Therefore, the bonding is based on the quality of surface preparation with the conditioner.[8] Instead of using PA, self-etching systems employ an acidic monomer as conditioner.[9] Self-etch adhesives can also be classified based on their acidity: mild (pH>2), intermediate (pH = 1–2), and strong (pH<1).[10] The acid etch technique dissolves hydroxyapatite and produces regular micro-pores; thus, increasing the surface area available for adhesion.[11] In self-etch adhesives, acidic functional monomers react to the mineral content of the tooth surface.[10] These monomers form highly hydrophilic interfacial structures, which make them more prone to water sorption., “All-in-one” adhesives, in particular, yield highly hydrophilic polymers which make them more permeable to fluid movement after polymerization.[12] The self-etching system is less time-consuming and less technique-sensitive.[13] Therefore, it can be beneficial in uncooperative patients, such as children.[14]

Studies have shown reliable and sufficient bond strengths to the dentin.[15] However, the efficacy of enamel bond strength is questionable.[16] Total etch adhesion systems are still considered as the gold standard amongst bonding systems.[17] However, clinicians have a tendency to use adhesive systems with simpler application procedures.[18]

Gardner et al. compared enamel etch patterns achieved on orthodontic bonding areas treated with PA and nitric acid (NA) using different etch times. The findings suggested that the use of PA provides a better quality etch than NA for all three application times.[19] Lopes et al. compared the shearbond strength to enamel produced by 5 self-etching primer/adhesive systems, one total etch, and one-bottle adhesive system. In their study, they reported Clearfil Self-Etch bond as the self-etching system and Single-bond as the total etch system with the strongest bond strength to enamel.[20] Nagayassu et al. investigated the microshearbond strength of different adhesives to human dental enamel. Only Adper Prompt L. Pop (a seventh generation adhesive system) revealed statistically lower bond strength compared to other adhesives.[21] Mine et al. studied bonding efficacy of two contemporary self-etch adhesives to enamel and dentin, and suggested that Adper Easy bond and Adper Scotch bond (new self-etch adhesives) strengths to enamel and dentin were generally lower than that of the control adhesive (Clearfil SE bond).[22] Moura et al. studied the bond strength to enamel using self-etching adhesive systems with different acids. They reported that the highest bond strength values were seen in the etch-and-rinse (total etch) adhesive systems.[23] Brachket et al. investigated microtensile dentin and enamel bond strength of recent self-etching resins. They concluded that adhesives with self-etching primers were as effective in bonding as the positive control (total etch products).[24] Miguez et al. suggested that acid etching should be carried outprior to the application of the self-etching primer so asto produce higher bond strength to enamel, instead of applying self-etching primer alone.[25] Poggio et al. also suggested surface pre-treatment with PA to increase the enamel bond strength of self-etch adhesives.[26] Nazari et al. also recommended pre-etching intact enamel surfaces prior to application of the adhesive instead of grinding so as to create a significantly rougher surface with higher bond strength.(27) Sabatini et al. suggested that pre-etching with PA adversely affected the dentin bond strength of self-etch adhesives, but improved the enamel bond strength for FL-Bond II (a two-step self-etch adhesive).(28) Puetzfeildet et al. investigated the effects of phosphoric acid and self-etching adhesives on the short and long-term bond strength of a light-cured sealant to unground primary and permanent enamel. They reported no significant difference in bond strengths between the phosphoric acid-etch and the self-etching adhesive groups. There was also no significant difference between the 1-week and 1-year results (P>.05). However, the bond strengths to primary enamel were lower than those to permanent enamel.(29)

Based on the literature reviewed above, adhesive systems, types of conditioners and a lack of sufficient studies investigating primary dentition enamel/dentin bond strengths, the authors of this study intended to compare the shearbond strength of composite restorations to intact enamel of primary incisors using different conditioners, and adhesive systems.

Materials and Methods

This experimental study was conducted in Shiraz University of Medical Sciences. 53 extracted primary incisors were collected and the crowns were cleaned of debris and soft tissue. The inclusion criteria for the present study were considered as intact non-carious enamel with no cracks or fractures following extraction procedure.

The teeth were stored in 1% chloramine solution at room temperature.

They were then embedded in chemically cured acrylic resin (Marlic Medical Industrial, Iran) cylinders. A specially fabricated cylindrical Teflon mold was filled with acrylic resin and allowed to cure, encasing each specimen wholly excluding the labial surface. Each tooth was oriented with the labial surface parallel to the shearing force. Before applyingthe adhesive system, the labial surface of each specimen was cleaned with fluoride free pumice in a rubberpolishing cup using a low speed hand-piece for 10 s. Theenamel surface was then rinsed with water to remove any pumice or debris and dried with an oilfree air stream. The teeth were classified into five groups based on the bonding procedure (see table 1 for detailed information on materials). In the first group (n=10), etching was performed using 2.5% NA for 30 s and the Margin bond adhesive system was used. In the second group (n=11), etching was performed using 35% PA for 30 s and the Margin bond (Coltene, Switzerland) adhesive system was applied according to the manufacturer's instruction. In the third group (n=11), enamel was treated with Tokuyama Bond Force (Tokuyama, Japan) using an applicator with light pressure. In the fourth group (n=10), etching was carried out using 10% maleic acid for 30 s and the Margin Bond system was applied. In the fifth group (n=11) the enamel surface was etched with phosphoric acid prior to the application of Tokuyama Bond Force adhesive system.

Table 1. Adhesive Systems Tested in Present Study

Material	Component	Type	General procedure
TOKUYAMA BOND FORCE	Phosphoric acid monomer, Bis-GMA*, triethylene glycol dimethacrylate, HEMA*, comphorquinone, alcohol, purified water	7th generation of adhesive bonding	Apply the adhesive using applicator, rub the adhesive using applicator under light pressure,apply lightair for 5s, blow the surface with strong air for 5s, light–cure for 10 s.
Margin Bond	Bis-GMA*, Bis-EMA*, TEGDMA*	5th generation of adhesive bonding	Apply a drop of MARGIN BOND on etched enamel, massage with a brush for 20s, blow with oil free compressed air, cure with halogen light for 20s.

*Bis-GMA =Bisphenol A Diglycidymethacrylate
*Bis-EMA= Bisphenol A Diethoxymethacrylate
*TEGDMA =triethylenglycoldimetacrylate
*HEMA =dihydroxymethylmetacrylate

Thereafter,1 mm thick micro-hybrid composite resin (Denfil, Korea) was carefully placed over the enamel surface by packing the composite into cylindricallyshaped objects with internal diameters of 2 mm and a height of 2 mm.

Excess composite was carefully removed using an explorer. The composite was then cured for 40 s using a Quartz-Tungsten-Halogen (QTH) lamp (ColtoLux75, Coltene WhaldentInc, Switzerland), according to the manufacturer's instructions. After composite build up, Teflon mold was removed and all specimens were kept in distilled water at 37°C for 24 h. The specimens were then placed in a universal testing machine (Zwick, Germany) at a crosshead speed of 1 mm/min. The amount of weight needed to detach the composite was recorded and the bond strength was measured using the following formula:

Bond strength = force needed to debond the composite (kg) × 9.8/total surface area

Statistical analysis

Results were interpreted with the standard deviations. Inter-group comparison of the shearbond strength to enamel was analyzed employing One-way-ANOVA and Tukey's post hoc test. Data were statistically analyzed using SPSS (Version 17, Chicago, IL, USA).

Results

Thisexperimentalstudywasconductedtocompare the shearbond strength of composite restorations to intact enamel of primary incisors when using different conditioners and adhesive systems. The mean ± standard deviation of shearbond strength of each group is illustrated in Table 2. Theresults of the ANOVA test showed a significant difference between experimental groups (p = 0.00). Tukey's post hoc test was employed to identify the significant difference between groups, the results of which are illustrated in Table 3. Based on the results shown in Table 2, the highest shear bond strength was found in the second and fifth groups and the lowest bond strength was found in the third group (p = 0.00).

Table 2. Mean and Standard Deviations of Shearbond Strength to Enamel for each Testing Group

Group	Number	Mean	Standard Deviation	P value
Group 1	10	9.7468	0.51296	
Group 2	11	11.9619	0.69324	
Group 3	11	2.3603	0.28893	P<0.001
Group 4	10	7.1417	0.64236	
Group 5	11	11.9050	0.55281	

Table 3. Comparison of Inter-Group Mean Differences in Shearbond Strengths

DependentVariable	(I)GROUP	(J)GROUP	Mean Difference	P value
Shear Bond Strength (MPa)	1	1	-2.21511	0.031
		2	7.38651	0.00
		3	2.60510	0.09
		4	-2.15822	0.00
	2	1	2.21511	0.031
		2	9.60162	0.00
		3	4.82021	0.00
		4	0.5689	1.00
	3	1	-7.38651	0.00
		2	-9.60162	0.00
		3	-4.78141	0.00
		4	-9.54473	0.00
	4	1	-2.60510	0.09
		2	-4.82021	0.00
		3	4.78141	0.00
		4	-4.76332	0.00
	5	1	2/15822	0.038
		2	-0.05689	1.00
		3	9.54473	0.00
		4	4.76332	0.00

Discussion

The highest shear bong strength is related to the second and fifth groups, and the lowest bond strength is related to the third group.

The high bond strength of the second group can be explained by the results of the study conducted by Gardner et al..[19] Their findings suggested that the use of PA provides a better quality etching pattern than NA. Good quality etches result in longer resin tags which can then result in higher bond strength to the enamel structure.

Lower bond strength of the fourth group in comparison with the second group could be explained by Hermsen et al.. Their study reported that PA removed significantly more enamel than maleic acid. Therefore, better bond strength is achieved using PA compared to maleic acid.[30]

Lower bond strength of the third group in comparison with the second group could be explained byVan Landuyt et al..[13] The bonding used in the present study had a mild pHlevel (pH> 2). Therefore, less enamel structure was removed and shearbond strength to the enamel was weak. On the other hand, based on Devarasa et al., the length of resin tags penetrating into the enamel structure is shorter for self-etch adhesive systems compared to 37% PA. Consequently, weaker bond strength to enamel is expected for self-etch adhesive systems.[31]

The high bond strength of the fifth group is due to application of PA prior to self-etching adhesive system so as to create longer resin tags in the enamel structure. According to Nazari et al.,[27] the high bond strength of the fifth group is due to low pH level of PA (pH < 1). This creates a more retentive enamel surface which, in turn, increases the shearbond strength to enamel.

It is hoped that the present study will contribute to the development of a better quality etching pattern with more reliable bonding strength. However, the study faced some limitations: this research was conducted in vitro whereas the oral cavity is an unstable environment. Different chemicals such as acids and different thermal cycles in the oral cavity can adversely affect the bond strength to enamel. It would also be ideal to investigate more self-etching adhesives with different acidities and under circumstances more similar to oral cavity conditions. Therefore, further studies are suggested in order to check the shearbond strength of different adhesive systems in clinical settings.

Conclusion

The fifth generation adhesive system with PA conditioner is still considered asthe gold standard. However, clinicians have a tendency to use adhesive systems with simple application procedures.[18] Based on the results of the present study, surface pretreatment with 37% PA accompanied by self-etching adhesive systemsinc reasessh earbond strength in vitro. This method can be further studied in clinical settings.

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