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Comparison of Shear-bond Strength of Composite Restoration to Intact Enamel of Primary Incisors Using Different Conditioners and Adhesive Systems

Ali Nozari¹, Ali Heidari², Ebrahim Azimi², Azade Rafiee³ ✉

¹ Department of Pediatric Dentistry, Dental School, Shiraz University of Medical Sciences, Shiraz, Iran

² Student Research Committee, Dental School, Shiraz University of Medical Sciences, Shiraz, Iran

³ Department of Pediatric Dentistry, Dental School, Shiraz University of Medical Sciences, Shiraz, Iran

Abstract

Background: Esthetic demands among patients have led to the introduction of tooth-colored restorations. Composite resins bond to enamel applying acid etch technique. Total etch adhesion systems are still considered as a golden standard among bonding systems. However, clinicians have tendency towards using adhesive systems with a simplified application procedure. The aim of the present study is to compare the shear-bond strength of composite restoration to intact enamel of primary incisors using different conditioners and adhesive systems. **Materials and Methods:** This experimental study was conducted at Shiraz University of Medical Sciences. 53 teeth were classified into 5 groups based on their bonding procedure. After composite build-up, specimens were placed in a universal testing machine at a cross-head speed of 1mm/min. Inter-group comparison of shear-bond strength to enamel was analyzed employing One-way-ANOVA and Tukey post-hoc test. Data were statistically analyzed using SPSS (Version 17, Chicago, IL, USA). **Results:** The highest shear-bond strength was related to the second (37% phosphoric acid etching + Margin Bond adhesive system), and the fifth group (37% phosphoric acid etch + Tokuyama Bond Force adhesive system). The lowest bond strength was related to the third group (Tokuyama Bond Force adhesive system alone) (P value = 0.00). **Conclusion:** Based on the results of the present study, surface pre-treatment with 37% PA accompanied by self-etching adhesive system, increased shear-bond strength in vitro. This method can be further studied in clinical settings. [GMJ. 2015;4(1):14-20]

Key Words: Shear-bond Strength; Enamel; Primary Incisor; Conditioner; Adhesive System

Introduction

Esthetic demands among patients have led to the introduction of tooth-colored restorative materials. Composite resins bond to enamel applying acid etch technique. However, dentin adhesion is not as predictable

as enamel bond [1]. Adhesion mechanism is based on the penetration of resin molecules into enamel and dentin. Tooth composite adhesion strength is an important factor in clinical durability of composite restoration [2]. Proper enamel adhesion has been achieved by means of phosphoric acid (PA) etching

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Fax: +98 731 2227091
PO Box 7461686688
Email: info@gmj.ir

✉ Correspondence to:

AzadeRafiee, Postgraduate Student, Department of Pediatric Dentistry, Dental School, Shiraz University of Medical Sciences, Shiraz, Iran
Telephone Number: (+98) 7116270325
Email Address: std2280197944@sums.ac.ir

[3]. However, dentin bonding is much more reliable than enamel bonding due to tubular structure, higher organic content and outward fluid flow in dentin [4]. Various bonding systems have been introduced in order to fulfill a reliable bond to tooth structure based on two main methods: the total etch and the self-etching systems. Total etch system is based on removal of smear layer and formation of collagen fibril layer by means of acid conditioner to form hybrid layer [5]. Collagen layer form is sensitive to desiccation. Therefore, tooth surface needs humidification [6]. Self-etching system is subdivided into two groups: two-step, and one-step self-etching. In one-step self-etch approach, conditioner primer, and adhesive are combined. No post-conditioning rinse is needed [7]. Therefore, bonding is based on the quality of surface preparation with 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 ($\text{pH} > 2$), intermediate ($\text{pH} = 1$ to 2), and strong ($\text{pH} < 1$) [10]. Acid etch application dissolves hydroxyapatite and produces regular micropores increasing the surface area for adhesion [11]. In self-etch adhesives, acidic functional monomers react to the mineral content of tooth surface [10]. These acidic functional monomers form highly hydrophilic interfacial structures making them more prone to water sorption. Particularly, “all-in-one” adhesives, which yield highly hydrophilic polymers, are much more permeable to fluid movement after polymerization [12]. Self-etching system is less time-consuming and less technique-sensitive [13]. As a result, it can be beneficial in uncooperative patients like children [14]. Studies have shown reliable and sufficient bond strength to dentin [15]. However, the efficacy of enamel bond strength is questionable [16]. Total etch adhesion systems are still considered as a golden standard among bonding systems [17]. However, clinicians have tendency towards using adhesive systems with simplified application procedure [18]. Gardner *et al.* compared enamel etch patterns achieved on orthodontic bonding area treated with PA and nitric acid (NA) at different etch times. Findings suggested that the use

of PA provides a better-quality etch than NA for all three application times [19]. Lopes *et al.* compared shear-bond strength to enamel of 5 self-etching primer/adhesive systems, one total etch, and one-bottle adhesive system. In their study, they reported Clearfil Self-Etch bond as a self-etching system, and Single-bond as a total etch system as having strongest bond strength to enamel [20]. Nagayasu *et al.* investigated the micro-shear-bond 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 effectiveness of two contemporary self-etch adhesives to enamel and dentin, suggesting that Adper Easy bond, and Adper Scotch bond (new self-etch adhesives) bond strength to enamel and dentin were generally lower than that of control adhesive (Clearfil SE bond) [22]. Moura *et al.* studied the bond strength to enamel using self-etching adhesive system with different acids. They reported that the highest bond strength values for etch-and-rinse (total etch) adhesive system [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 positive control (total etch products) [24]. Miguez *et al.* suggested acid etching should be prior to the application of self-etching primer in order to produce higher bond strength to enamel rather than self-etching primer alone [25]. Poggio *et al.* also suggested surface pretreatment with PA to increase enamel bond strength of self-etch adhesives [26]. Nazari *et al.* also recommended pre-etching intact enamel surface prior to the application of adhesive instead of grinding to create a significantly rougher surface with higher bond strength [27]. Sabatini *et al.* suggested that the pre-etching step with PA adversely affected the dentin bond strength of self-etch adhesives, while providing improvement on enamel bond strength only for FL-Bond II (a two-step self-etch adhesive) [28]. Puetzfeildet *et al.* investigated the effect of phosphoric acid and a self-etching adhesive on both short and long-term bond strengths

of a light-curing sealant to unground primary and permanent enamels. They reported neither significant difference in bond strengths between phosphoric acid-etch and the self-etching adhesive groups, nor between 1-week and 1-year results ($P>.05$). However, the bond strengths to primary enamel were lower than those of permanent enamel [29].

Following controversies reviewed above, adhesive system and the type of the conditioner and lack of sufficient studies on primary dentition enamel/dentin bond strengths, researchers intended to compare the shear-bond strength of composite restoration to intact enamel of primary incisors using different conditioners, and adhesive systems.

Methods and Materials

This experimental study was conducted at Shiraz University of Medical Sciences. 53 extracted primary incisors were collected. Crowns were cleaned of debris and soft tissue. Inclusion criteria for the present study were considered as intact non-carious enamel with no crack or fracture caused by extraction. Teeth were kept in 1% chloramines solution at room temperature during storage period. The teeth were, then, embedded in chemically-cure acrylic resin (Marlic Medical Industrial, Iran) cylinders. A specially fabricated cy-

lindrical Teflon mold was filled with acrylic resin and allowed to cure thus encasing each specimen except for the labial surface. Each tooth was oriented with the labial surface parallel to shearing force. Before applying adhesive system, the labial surface of each specimen was cleaned with fluoride-free pumice in a rubber-polishing cup with a low speed hand-piece for 10 seconds. Enamel surface was then rinsed with water to remove any pumice or debris, and then was dried with an oil-free air stream. Teeth were classified into 5 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 sec. and the Margin bond adhesive system. In the second group ($n=11$), etching was performed using 35% PA for 30 sec. and the Margin bond (Coltene, Switzerland) adhesive system was applied based on the manufacturer instruction. In the third group ($n=11$), enamel was treated with Tokuyama Bond Force (Tokuyama, Japan) using applicator with light pressure. In the fourth group ($n=10$), etching was applied using 10% maleic acid for 30 sec. and the Margin Bond system. In the fifth group ($n=11$), 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	7 th generation of adhesive bonding	Apply the adhesive using applicator – rub the adhesive using applicator under light pressure – light air for 5second - blow the surface with strong air for 5s –light – cured for 10
Margin Bond	Bis-GMA*, Bis-EMA‡, TEGDMA**	5 th 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

*HEMA =dihydroxymethylmetacrylate

*Bis-EMA = Bisphenol A Diethoxymethacrylate

*TEGDMA =Triethyleneglycoldimetacrylate

After that, 1mm thick microhybrid composite resin (Denfil, Korea) was carefully placed over the enamel surface by packing composite into cylindrically-shaped materials with internal diameters of 2 mm and a height of 2 mm. Excess composite was carefully removed using an explorer. Composite was cured for 40 sec. using a Quartz-Tungsten-Halogen (QTH) lamp (ColtoLux75, Coltene Whaldent Inc, Switzerland) according to manufacturer's instruction. After composite build-up, Teflon mold was removed and all specimens were kept in distilled water at 37°C for 24 hours. Then, specimens were placed in a universal testing machine (Zwick, Germany) at a crosshead speed of 1mm/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) $\times$ 9.8 / total surface area.

Statistical Analysis

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

Results

This experimental study was conducted to compare shear-bond strength of composite restoration to intact enamel of primary incisors using different conditioners, and adhesive systems. The mean $\pm$ standard deviation of shear-bond strength of each group is illustrated in table 2. Result of ANOVA test showed a significant difference among experiment groups (p value = 0.00). Tukey post hoc

test was employed to recognize significant differences among groups. Results of Tukey post hoc test are illustrated in table 3.

Based on the results shown in table 2, the highest shear bond strength is related to the second and fifth groups and the lowest bond strength is related to the third group (P = 0.00).

Discussion

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

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

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

Lower bond strength of the third group in comparison with the second group could be explained according to Van Landuyt *et al.* [13]. The bonding used in the present study had mild Ph. level (Ph > 2). Therefore, less enamel structure was removed and shear-bond strength to enamel was weak.

On the other hand, based on Devarasa *et al.*, the length of resin tags penetrating into enamel structure is shorter for self-etch adhesive systems than 37% PA. Consequently, weaker bond strength to enamel is expected for self-etch adhesive systems than 37% PA [31].

High bond strength of the fifth group is due

Table 2. Mean and Standard Deviation of Shear-bond Strength to Enamel for each Testing Group

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

Table 3. Comparison of Inter-Group Mean Differences of Shear-bond Strengths

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

to application of PA prior to self-etching adhesive system to create longer resin tags in enamel structure. According to Nazari *et al.* [27], Meola *et al.* [32], and Shinchi[33] 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 shear-bond strength to enamel.

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

Conclusion

The fifth generation adhesive systems with PA conditioners are still considered as a golden standard. However, clinicians have tendency towards using adhesive systems with simply applicable procedures[18]. Based on the results of the present study, surface pretreatment with 37% PA accompanied by a self-etching adhesive system, increases shear-bond strength in vitro. This method could further be studied in clinical settings.

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