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Effect of Dentin Pretreatment with Chlorhexidine on Push-Out Bond Strength of Composite Restorations in Severely Damaged Primary Anterior Teeth

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A B S T R A C T

Objectives: Achieving durable restorations with adequate strength in severely damaged primary anterior teeth in children is a priority. The aim of this study was to investigate the effect of dentin pretreatment with chlorhexidine on push-out bond strength of composite restorations.

Materials and Methods: In this in vitro experimental study, 56 extracted primary anterior teeth were randomly divided into 4 groups: (1) saline and total-etch bonding agent, (2) chlorhexidine and total-etch bonding agent, (3) saline and self-etch bonding agent, and (4) chlorhexidine and self-etch bonding agent. After the application of bonding agents, the post space was filled with Z250 composite resin. Following thermocycling of the samples, the push-out test was performed using a universal testing machine, and the results were analyzed with two-way ANOVA.

Results: The mean push-out bond strength values in groups 1 to 4 were 5.7, 8.39, 5.35, and 7 MPa, respectively. Chlorhexidine groups had significant differences with saline groups in bond strength ($P<0.05$) but there was no statistically significant difference between the self-etch and total-etch bonding agents in the groups ($P>0.05$).

Conclusion: Both types of bonding agents (self-etch and total-etch) exhibited favorable results in radicular dentin of primary anterior teeth; however, pre-treatment with chlorhexidine increased the push-out bond strength of composite restorations in primary anterior teeth.

Keywords: Chlorhexidine; Dental Bonding; Tooth, Deciduous

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INTRODUCTION

Dental caries is one of the most common chronic diseases in children [1]. Early childhood caries refers to the presence of one or more decayed or restored areas on the surface of primary teeth in children under 71 months of age [2-4]. Teeth that are often affected by early childhood caries include the upper central and lateral incisors, and the upper and lower first molars [4,5]. It has a rapid progression and quickly destroys the crown of the tooth, and leads to early dental pulp involvement. In severe cases, the tooth crown is completely destroyed [2].

Preserving the integrity of the primary dentition is important until the primary teeth are normally replaced by their permanent successors [6]. Early loss of the primary anterior teeth may have some consequences such as reducing the effectiveness of chewing, loss of vertical dimension of occlusion, parafunctional habits (tongue thrusting and mouth breathing), speech problems (disturbances in the pronunciation of fricative sounds, e.g. F and S), development of malocclusion, and delayed eruption of permanent teeth [1,7].

Small size of primary teeth (compared with permanent teeth) and young age of patients complicate the restoration of primary teeth [8]. One available treatment option for restoration of severely damaged primary teeth is to use intracanal posts along with composite resin. In such cases, effective bonding of tooth-colored restorative materials to the tooth structure is highly important. In cases where part of the coronal tooth structure remains, teeth with intracanal posts often have a better performance than those without a post. Also, in such cases, fabrication of posts with composite resin is necessary for bonding and stability of the composite crown and resistance to masticatory forces. Therefore, it is recommended to fabricate intracanal posts after pulpectomy [9-11]. Composite posts have been used for primary teeth since 1986 and provide satisfactory results in presence of normal masticatory function, and a balanced diet [12].

Adhesive systems have different mechanisms for obtaining a strong, durable bond to enamel and dentin. Penetration and polymerization of a hydrophilic monomer that can react with the exposed collagen network in the dentin matrix lead to the formation of a hybrid layer (resin-dentin inter-diffusion), which is generally accepted as the main factor for achieving the desired bond strength [13].

It is very important to prepare a post space, effectively remove the smear layer, and provide proper access to dentin for effective bonding to decalcified dentin.

Chlorhexidine is suggested as an endodontic irrigant due to its extensive antimicrobial effects, durability, biocompatibility, and favorable physicochemical properties. Chlorhexidine can prevent decomposition of collagen fibers and preserve the hybrid layer [14]. Since there is limited information about bonding to pulp chamber dentin or primary root canals in previous studies, it is necessary to examine the use of the most suitable bonding systems in order to increase the bond strength and preserve the primary teeth. Therefore, the present study aimed to compare the push-out bond strength of restorations of severely damaged anterior teeth with and without chlorhexidine pretreatment, using self-etch and total-etch bonding systems, to help clinicians choose the most appropriate treatment modality to restore primary teeth.

MATERIALS AND METHODS

This in vitro experimental study was approved by the Ethics Committee of Tehran University of Medical Sciences, Tehran, Iran (ethical code: TUMS. 2017.9011272022). The present study was performed on 56 extracted primary anterior teeth. The teeth were kept in saline solution, which was refreshed weekly. Prior to the onset of the experiment, the samples were disinfected by immersion in 0.5% chloramine T solution for 1 week in a refrigerator at 4°C. The crown of each tooth was cut by a high-speed handpiece (Pana-Max, Kanuma Tochigi, Japan) and a diamond fissure bur 1 mm above the cementoenamel junction.

The apex of each tooth was sealed with a light-cure liner to preserve the filling material in the root canal, provide an apical seal, and ensure standardization of the samples during the preparation stages.

The root canals were shaped by circumferential filing with K-files (Mani lnc. Tochigi, Japan) and irrigated with saline solution. They were dried with paper points (PT Dent; Brookline, MA, USA) and then filled with zinc oxide eugenol to 5 mm apical to the cutting level (4 mm apical to the cementoenamel junction) to provide a space for composite post placement. One millimeter of light-cure liner (Lime-lite Light-Cure Cavity Line; Pulpdent Co., Watertown, MA, USA) was applied over the root canal filling material. The liner was then light-cured for 30 s using a LED curing unit (Woodpecker, Guilin, Guangxi, China). The excess material was cleaned such that there was a 4-mm space in the coronal part of each tooth (3 mm from the cemento-enamel junction) for placement of composite in the canal. The teeth were randomly divided into 4 groups:

Group 1: The teeth were irrigated with saline solution. The steps were as follows: 15 s of etching, 10 s of irrigation, drying the dentin with dry cotton pellets, drying with air spray while a cotton pellet was placed in the canal to prevent excessive drying of dentin until the frosty appearance of the enamel was visible in the cementoenamel junction area, use of 2 layers of total-etch bonding agent (Single Bond 2; 3M ESPE, St. Paul, MN, USA), 5 s of gentle air-drying, and light-curing for 10 s (according to the manufacturer's instructions).

Group 2: In this group, 2% chlorohexidine solution was applied to the root canal with a syringe and left in the canal for 60 s; then, excess moisture was removed with paper points. The etching and drying steps were performed as described for the first group. Two layers of total-etch bonding agent (Single Bond 2; 3M ESPE, St. Paul, MN, USA) were applied, gently air-dried for 5 s, and light-cured for 10 s.

Group 3: The teeth were irrigated with saline solution and dried with paper points. Self-etch adhesive (Single Bond Universal; 3M ESPE, St. Paul, MN, USA) was applied for 20 s. Then, it was gently air-dried for 5 s, and light-cured for 10 s (according to the manufacturer's instructions).

Group 4: In this group, 2% chlorhexidine solution was applied to the root canal for 60 s by a syringe. Excess moisture was removed by paper points. Self-etch adhesive (Single Bond Universal; 3M ESPE, St. Paul, MN, USA) was applied for 20 s. Then, it was gently air-dried for 5 s, and light-cured for 10 s.

Finally, the root canals in the four groups were filled with a conventional composite (Z250; 3M ESPE, St. Paul, MN, USA) with the incremental technique using 2-mm increments, followed by 40 s of light-curing for each layer. Composite was applied up to 1 mm above the crown cutting level. The LED curing unit (Wood Pecker, Guilin, Guangxi, China) had a constant intensity of 600 mW/cm^2 for all the samples, and the tip of the light-curing unit was in contact with the sectioned tooth surface during the light-curing process. Next, the teeth filled with composite were thermocycled (TC300; Vafaei Industrial Company, Tehran, Iran) for 500 cycles at 5-55°C with a dwell time of 20 s and a transfer time of 10 s. After thermocycling, the samples were mounted in polyester blocks, and 1-mm thick slices were sectioned at the mid-root in a pre-prepared area by a cutting machine (T201 A Mecatome; Presi, France). The diameter of both sides of the composite section was measured under a stereomicroscope (SMZ800; Nikon, Tokyo, Japan) by the MIP software at x5 magnification and standard calibration.

The bond strength was determined by the push-out test using a universal testing machine (2050; Zwick/Roell, Ulm, Germany). Load was applied by a cylindrical stainless steel plunger with a diameter proportional to the canal diameter at a crosshead speed of 0.5 mm/min in apicocervical direction. Maximum load to the desired region at the time of composite debonding was recorded in Newtons (N). The previously calculated load in Newtons was divided by the cross-sectional area in square-millimeters (mm^2) to report the push-out bond strength value in megapascals (MPa). The cross-sectional area was calculated using the following formula:

$$S = H\left(\frac{A1 + A2}{2}\right)$$

H: The height of the root cross-section
A1: Apical section perimeter of the root canal
A2: Coronal section perimeter of the root canal
S: Cross-section in square-millimeters (mm^2)

Finally, data were collected and statistically analyzed. Two-way ANOVA was used to compare the push-out bond strength between the groups. Statistical analyses were performed using SPSS version 25 with α=0.05.

RESULTS

According to the data presented in Table 1 and data analysis by two-way ANOVA, the interaction effect of irrigating solution and bonding agent was not significant on bond strength (P=0.406).

Table 1. Maximum (max), minimum (min), mean and standard deviation (SD) of bond strength (MPa) of primary anterior tooth restorations in all groups

Irrigating solution	Bonding agent	Min	Max	Mean±SD
Serum	Total-etch	1.36	10.96	5.28±2.84
	Self-etch	1.34	13.75	5.36±3.72
Chlorhex-idine	Total-etch	6.10	10.22	8.40±1.26
	Self-etch	5.40	15.36	7.01±4.45

Thus, in general, Single Bond 2 (total-etch) and Single Bond Universal (self-etch) were not significantly different in bond strength (P=0.459). On the other hand, the effect of irrigating solution on bond strength was significant, and the mean bond strength of the chlorhexidine pretreatment group was significantly higher than that of the saline group (P=0.009).

DISCUSSION

The present study examined the effect of dentin pretreatment with chlorhexidine on the push-out bond strength of composite restorations bonded with self-etch (7^{th} generation) and total-etch (5^{th} generation) adhesives.

Pairwise comparisons showed no significant difference between group 1 (saline and total-etch) and group 3 (saline and self-etch), and group 2 (chlorhexidine and total-etch) had no significant difference with group 4 (chlorhexidine and self-etch). It means that the type of bonding agent had no significant effect on bond strength. The mean bond strength in groups 2 and 4 was significantly higher than that in groups 1 and 3, indicating significant differences between the chlorhexidine and saline groups.

Afshar et al. [15] examined the push-out bond strength of 5^{th}, 6^{th}, and 7^{th} generation adhesives to the root dentin of primary anterior teeth and reported no significant difference. The mean bond strength of the 5^{th} generation (Single Bond 2) and 7^{th} generation (Single Bond Universal) adhesives was not significantly different; while in both groups, the mean bond strength was higher than that in the present study, which can be attributed to the lack of thermocycling of the samples. In the present study, the bond strength was higher in the groups that underwent chlorhexidine pretreatment.

Maintaining the integrity of the collagen matrix improves the durability of the bond to dentin. Enzymatic degradation of collagen network plays an important role in destruction of the dentin-resin interface. Some matrix metalloproteinases have been identified in human dentin and are introduced as the causes of degradation. Chlorhexidine is one of the most widely used inhibitors of matrix metalloproteinases [16].

Chlorhexidine can compensate for the reduced dentin-composite bond strength during long-term storage in water and, retains the characteristics of the hybrid layer by inhibition of host proteases. Erdemir et al. [17] reported that irrigation with chlorhexidine significantly increased the bond strength to root dentin.

The possible effects of chlorhexidine are attributed to the release of positively-charged molecules in surfaces treated with chlorhexidine, and its ability to adsorb onto surfaces in the oral cavity. Theoretically, this process also occurs in demineralized exposed collagen fibers and is a fundamental reason for maintaining the bond strength.

Kim and Shin [18] investigated the effects of chlorhexidine application on bond strength of resin cores to the axial dentin in endodontic cavities. Smooth dentin surfaces in 40 endodontic cavities underwent microtensile bond strength test after the application of self-etch and total-etch adhesive systems (Adper Single Bond 2) with/without the use of chlorhexidine and thermocycling. Their study was different from ours since they used permanent teeth and a self-etch bonding agent. Also, the type of bond strength test was different in their study from the present study. Thus, it is not possible to examine the details of the differences in the mean bond strength between the two studies, but some points in their study are remarkable: The use of self-etch or total-etch bonding agents made no difference in the mean bond strength of composite restorations to the dentinal walls of endodontic cavities and pulp chambers. The use of chlorhexidine solution had a significant effect on increasing the bond strength of composite to dentin in the endodontic cavity (in samples undergoing thermocycling). In our study, there was no significant difference between the self-etch and total-etch bonding systems.

Although the hybrid layer created by the total-etch systems is thicker than that created by the self-etch systems, the comparison of bond strength between different bonding systems yields variable results [19]. The hybrid layer is not a major requirement for success, and the dentin bond strength is probably proportional to the resin and collagen interlocking, as well as the quality of the hybrid layer [20]. Evidence shows that the bond strength is affected by three factors of pH, solvent properties, and filler content of the adhesive [21].

Since the number and diameter of the dentinal tubules in the primary teeth are more than the corresponding values in permanent teeth, the substrate available for bonding to the adhesive in primary teeth is reduced [22]. Since acid penetration occurs initially into the tubules, presence of larger dentinal tubules in primary teeth could lead to deeper penetration of the acidic conditioner, and resultantly stronger demineralization [23]. Considering the fact that the acid used to prepare the dentin surface removes the smear layer in the primary teeth faster than in permanent teeth, shorter conditioning time or a weaker acidic solution is recommended for primary teeth. Studies have shown that shorter conditioning time in primary teeth, in addition to smear layer dissolution, leads to a surface morphology similar to conditioned permanent tooth dentin [15,24]. In this study, the pH level of both adhesive systems was mild (pH>2).

The solvent used is primarily water, and acetone or ethanol in some bonding systems.

Water-based bonding systems result in lower bond strength due to incomplete monomer polymerization [13,23]. The solvents in both types of bonding agents in this study were water and ethanol.

According to some studies, filler-containing bonding systems affect the bond strength of resins [13,21]. Presence of filler in the bonding agent results in formation of a thicker resin layer and stabilization of the hybrid layer. The bonding agents used in this study contained filler, which was effective in creating the required bond strength.

In a study by Ricci et al, [25] application of 2% chlorhexidine on primary and permanent teeth and use of Single Bond 2 and Prime & Bond NT total-etch bonding agents led to a significant increase in microtensile bond strength. Shirinzad et al. [26] investigated the effect of several root canal irrigating solutions on quartz fiber posts bonded with resin cement to permanent teeth. In their study, dentin post space pretreatment with 2% chlorhexidine significantly increased the tensile bond strength, compared with other irrigants.

It should be noted that the present study was conducted in an in vitro setting; it is necessary to perform clinical trials in order to obtain more accurate results because in the oral cavity, conditions such as continuous and long-term thermal alterations, pH changes, masticatory forces, and different enzymes and bacteria can affect the bond strength of composite posts.

CONCLUSION

Based on the results of this study and considering the limitations of in vitro studies in general, it can be concluded that pretreatment with chlorhexidine has a positive effect on the push-out bond strength of composite to dentin in the root canal of primary anterior teeth. In addition, due to the optimal antimicrobial properties and absence of harmful properties such as burning sensation, bad smell, etc., chlorhexidine can be used as an appropriate root canal irrigant in children.

CONFLICT OF INTEREST STATEMENT

None declared.

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