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The Effect of the Type of Post Space Irrigation on the Push-Out Bond Strength of Glass Fiber Post (An in vitro Study)

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ABSTRACT

Aim: The study aims to evaluate the effect of different irrigant and ultrasonic activation on the push-out bond strength of glass fiber post to the root dentine.

Materials and Methods: Palatal roots of sixty-four maxillary first molar teeth were sectioned at 14 mm and instrumented with ProTaper Next rotary system up to X4 and obturated with AH Plus sealer and gutta-percha size X4. After post space preparation, the samples were divided into eight groups (n=8) according to the post space irrigation as follow; normal saline (control group), normal saline with ultrasonic activation, 5.25% NaOCl, 5.25% NaOCl with ultrasonic activation, 2% chlorhexidine, 2% chlorhexidine with ultrasonic activation, 17% EDTA and 17% EDTA with ultrasonic activation. RelyX fiber posts were cemented with RelyX U200 cement, the samples were sectioned horizontally, and two slices were obtained from each sample. A push-out test was performed using the Universal testing machine at a speed of 0.5mm/min. The statistical analysis involved One-way ANOVA with post hoc Bonferroni test and Student's t-test.

Results: irrigation protocol significantly affected the bond strength ($p < 0.001$), EDTA showed the highest bond strength and NaOCl showed the lowest bond strength. Ultrasonic activation did not significantly improve the bond strength ($P>0.05$). The apical regions have significantly higher bond strength than coronal regions ($p < 0.001$).

Conclusion: post space irrigation with 17% EDTA significantly improved the bond strength of fiber post to root dentine using self-adhesive cement, while the ultrasonic activation of the irrigant solutions had no effect on the bond strength.

Key words: Fiber post, Bond strength, Self-adhesive cement, Irrigation

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INTRODUCTION

The achievement of reliable bonding to the root canals dentine is challenging due to the unfavorable geometrical shape of the canal and the imperfections of the physical properties of the adhesive materials. In addition, endodontic procedures performed before the cementation of posts may interfere with the bonding to root canal walls [1]. As debonding is the common reason for fiber post failure clinically [2], it is important to obtain good bond strength of the fiber post to the root canal walls. The adhesion to radicular dentine is a complicated and technique sensitive process; therefore, the self-adhesive cement has been developed to simplify the technique and improve the bonding of fiber posts to the radicular dentine [3].

Root dentine treatment with various solutions may change the structural and chemical composition of the dentine, which may cause alteration in the dentine solubility and permeability [4]. Such alteration may influence the bonding capability of the adhesive agents to the dentine [5]. Sodium hypochlorite (NaOCl) is used as an irrigant in endodontic treatment due to its wide-spectrum antimicrobial activity and its properties as a tissue solvent; however, it is unable of smear layer removal alone, as it does not affect the inorganic materials [6]. Ethylene diamine tetra acetic acid (EDTA) effectively dissolves the inorganic materials, especially the smear layer and does not possess antibacterial activity [6].

Chlorhexidine (CHX) is a suitable irrigant solution because of its wide-spectrum antibacterial action, tissue compatibility and does not interact with the dentinal organic phase; thus, properties of the dentine are preserved. Also, it is unable of dissolving the tissues [7]. Numerous activation systems have been developed for more efficient removal of bacteria and dentinal debris from the root canals, such as passive ultrasonic irrigation (PUI). PUI is the ultrasonic activation of the root canal irrigant solutions through a small oscillating file placed inside the root canal after mechanical instrumentation [8]. Null hypothesis: there is no effect of different irrigant solutions on the push-out bond strength of the fiber post; there is no effect of ultrasonic activation on the push-out bond strength of the fiber post.

MATERIALS AND METHODS

Sixty-four extracted human maxillary first molar were selected with the selection criteria that included: Straight palatal root, circular canal and absence of root decay, external root resorption or cracks. Diagnostic X-ray was taken to verify the presence of a single canal, fully formed apex and absence of internal root resorption or previous root canal treatment. The palatal roots were sectioned to a length of 14 mm from the apex. Canal patency was verified by the insertion of K file size #10 until the file tip was barely visible through the apical foramen. The working length was determined by subtracting 1 mm from this length. Initially, all the root specimens were negotiated with K files #10 and #15. After that, All the roots were instrumented with ProTaper Next rotary files (Dentsply, Maillefer, Switzerland) X1, X2, X3 up to X4. The rotation speed of the endo motor E-connect pro (Eighteeth, china) was set at 300rpm and the torque at 2 Ncm according to the manufacturer instructions. The root canals were irrigated with 3 mL of 5.25% NaOCl between each file. After complete instrumentation, the canals were irrigated with 3 mL of 17% EDTA solution, 3 mL of 5.25% NaOCl, and a final rinse with 3ml of distilled water.

After dryness with paper points, the root canals were obturated with the master gutta-percha cone (X4) and AH Plus sealer (Dentsply, Konstanz. Germany) using the single cone obturation technique. The coronal orifices of all roots were sealed with glass ionomer cement and stored for one week at 37°C and 100% humidity. After that, the gutta-percha at the coronal and middle thirds was removed with Gates Glidden size #1 (Mani, china) and the post space was prepared with RelyX fiber post drill size #1 (yellow) (3M ESPE, Germany) to a depth of 10 mm, leaving 4mm of apical obturation materials to preserve the apical seal. Samples were divided into eight groups according to the irrigation protocol (n=8).

NS1 group: post spaces irrigation with 5 ml of 0.9% normal silane solution (control group).

NS2 group: post spaces irrigation with 5 ml of 0.9% normal silane solution with PUI.

SH1 group: post spaces irrigation with 5 ml of 5.25% NaOCl solution.

SH2 group: post spaces irrigation with 5 ml of 5.25% NaOCl solution with PUI.

CH1 group: post spaces irrigation with 5 ml of 2% CHX solution.

CH2 group: post spaces were irrigation 5 ml of 2% CHX solution with PUI.

ET1 group: post spaces irrigation with 5 ml of 17% EDTA solution.

ET2 group: post spaces irrigation with 5 ml of 17% EDTA solution with PUI.

For NS1, SH1, ET1 and CH1 groups, the needle was inserted 1 mm shorter than post space length with 2-3 mm apical-coronal movements. Then the solutions were left for 1 min to standardize the total time of 90 sec. Ultrasonic activation was performed with a piezoelectric ultrasonic unit UltraX (Eighteeth, China) at a power setting of 45000 Hz using stainless-steel ultrasonic endo tip (size #20,0.02) at 1 mm shorter than post space length with 2-3 mm apical-coronal movement, three cycles of ultrasonic activation each for 20 seconds were applied with an intermittent flush of tested solution each for 10 sec (total 90 sec). The post spaces of all groups were flushed with 5 ml of distilled water for 30 sec. To standardize the flow rate of 1 ml/ 6 sec, a modified irrigation device (oral care, china) with Navi tip gauge 31 was used. After post space dryness with paper points, the self-adhesive resin cement RelyX U200 Automix (3M ESPE, Germany) was applied directly to the post space by endo tip (3M ESPE, Germany) and RelyX fiber post size #1 (yellow) (3M ESPE, Germany) was fully seated in the post space. The excess material was removed immediately with a micro brush and the fiber post was kept under figure pressure for 1 minute. Light curing was done with a LED curing unite (LED, Guilin Woodpecker Medical Instrument CO, China) for 40 sec at 850 mW/cm2 intensity with the tip of the curing unit was in direct contact with the coronal end of the fiber post. After embedment in clear acrylic, the samples were sectioned horizontally perpendicular to their long axis by a diamond disk under water coolant to obtain two sections (2 mm thickness) from the coronal and apical regions. Push-out test was performed by a Universal testing machine (Tinius Olsen, UK) at a speed of 0.5mm/min; due to the tapered design of the fiber post, each side of the slice was photographed using a Nikon camera with a macro lens and the diameters of the post were measured with Image J software program. Two different sizes of flat-ended plungers were used to contact only the fiber post without touching the cement and/or the dentinal walls. The maximum failure load was recorded in newtons (N) and then converted to megapascals (MPa) from the flowing equation:

Push-out bond strength (MPa) = Maximum load (N)/Adhesive area (mm2)

Adhesive area (A) recorded from:

$A=\pi\ (R+r)\ [(h^2+(R-r)2]0.5$

$\pi=3.14$.

R: Represents the coronal post radius (mm).

R: Represents the apical post radius (mm).

H: Represents the thickness of the slice (mm).

The failed specimens were examined under a digital microscope (at 50X magnification) to analyze the failure pattern; the failure mode was classified as: adhesive failure between resin cement and dentine (A c/d), adhesive failure between resin cement and post (A c/p), mixed adhesive failure (M) and cohesive failure in the post (Cp). One-way ANOVA with post hoc Bonferroni test and Student's t-test were performed to identify the significant differences among the groups (a=0.05).

RESULTS

Means push-out bond strength (Table 1) showed that ET1 and ET2 groups had the highest bond strength, while SH1and SH2 groups had the lowest bond strength. Student's t-test (Table 1) showed significant differences ($p < 0.001$) between the coronal and apical regions of all the groups. Student's t-test (Table 2) showed that there were non-significant differences ($P>0.05$) between the groups with PUI and the groups without PUI at both regions. One-way ANOVA test showed a significant difference ($p < 0.001$) among all groups at both regions. To locate the source of significant difference Bonferroni test (Table 3) was performed among NS1, SH1, CH1 and ET1 groups and showed that at the coronal region, there were significant differences when comparing (NS1-ET1), (SH1-CH1), (SH1-ET1), (CH1-ET1) groups, while non-significant differences when comparing (NS1-SH1) and (NS1-CH1) groups. At the apical region, there were the same results except that there was a non-significant difference between (CH1-ET1) groups. Bonferroni test among PUI groups showed similar results. The percentage of the failure mode (Table 4) showed that the mixed adhesive failure (M) was the predominant failure mode in NS1, NS2, CH1, CH2, ET1 and ET2

Table 1: Mean push-out bond strength with standard deviation and Student's t-test between coronal and apical regions.

Groups	Coronal		Apical		Student's t-test Coronal vs. Apical		
	Mean	±SD	Mean	±SD	t-test	P-value	Sig.
NS1	18.28	1.36	24.39	0.82	-10.831	0	S
NS2	18.51	1.23	24.77	0.82	-11.943	0	S
SH1	16.02	2.43	22.53	2.21	-5.594	0	S
SH2	16.38	1.06	23.06	1.35	-10.944	0	S
CH1	20.21	1.09	26.52	1.23	-10.82	0	S
CH2	20.25	1.51	26.6	1.61	-8.108	0	S
ET1	23.06	1.87	28.45	1.8	-5.857	0	S
ET2	23.52	1.43	28.95	1.45	-7.517	0	S

Table 2: Student's t-test between groups with and without PUI.

Groups	Regions	t-test	P-value	Sig.
NS1 vs. NS2	Coronal	-0.353	0.729	NS
	Apical	-0.922	0.372	NS
SH1 vs. SH2	Coronal	-0.39	0.703	NS
	Apical	-0.574	0.575	NS
CH1 vs. CH2	Coronal	-0.059	0.954	NS
	Apical	-0.108	0.916	NS
ET1 vs. ET2	Coronal	-0.557	0.586	NS
	Apical	-0.614	0.549	NS

Table 3: Bonferroni test among NS1, SH1, CH1 and ET1 groups.

Region	Variable	Mean Difference	P-value	Sig.
Coronal	NS1-SH1	2.2625	0.15	NS
	NS1-CH1	-1.93125	0.46	NS
	NS1-ET1	-4.77875	0	S
	SH1-CH1	-4.19375	0	S
	SH1-ET1	-7.04125	0	S
	CH1-ET1	-2.8475	0.016	S
Apical	NS1-SH1	1.86125	0.422	NS
	NS1-CH1	-2.125	0.165	NS
	NS1-ET1	-4.05625	0	S
	SH1-CH1	-3.98625	0	S
	SH1-ET1	-5.9175	0	S
	CH1-ET1	-1.93125	0.331	NS

Table 4: Failure modes percentage of all groups.

Groups	Adhesive c/d	Adhesive c/p	Mixed adhesive	Cohesive p
NS1	31.25%	0%	43.75%	25%
NS2	31.25%	12.50%	43.75%	12.50%
SH1	62.50%	0%	18.75%	18.75%
SH2	62.50%	0%	25%	12.50%
CH1	12.50%	18.75%	37.50%	31.25%
CH2	25%	0%	62.50%	12.50%
ET1	6.25%	18.75%	50%	25%
ET2	0%	25%	50%	25%
Total	28.90%	9.37%	41.40%	20.31%

groups, while the adhesive failure between resin cement and dentine (A c/d) was the predominant failure mode in SH1 and SH2 groups.

DISCUSSION

The most common failure cause in fiber post retained restoration is debonding. The bonding quality is influenced by several factors such as; the anatomy of the root, unfavorable cavity configuration, cement application procedure, polymerization technique, smear layer and others [9].

According to the results of the study, the irrigant solutions had significantly influenced the bond strength of fiber post to radicular dentine; therefore, the first part of the null hypothesis must be rejected, and this agreed with these studies [10,11]; however, another study observed less influence of irrigant solutions on the bond strength of fiber post cemented with self-adhesive cement [12].

A thick smear layer is formed during the preparation of post space; this smear layer led to a significant reduction of the self-adhesive cement bond strength due to the interference with the formation of the hybrid layer [13]. This can be attributed to the reduced ability of acidic monomers of self-adhesive cement to dissolve this thick layer and penetrate the underlying dentine surface [14].

In the present study, the highest bond strength was observed in ET1 and ET2 groups; this could be attributed to its best ability of removing the smear layer compared with other tested solutions [12]. Furthermore, EDTA has the potential to improve the wettability of dentine surface and it is always the first option whenever the adhesion is considered [15].

This finding agreed with these studies [16,17]. In contrast, Hayashi, et al. [18] reported significantly lower bond strength after 17% EDTA irrigation; these different results could be due to the use of different dentine bonding systems (self-etching cement).

2% CHX irrigation exhibited slighter improvement in the bonding strength, but the difference was statically non-significant from the control group. CHX is a MMP inhibitor that protects the collagen of the hybrid layer from degradation leading to bond strength preservation of the acid-etched dentine, however; its effect could be demonstrated in a long-term evaluation. Therefore, it is possible that the short period evaluation may influence the results of the present study.

Another explanation might be that the self-adhesive cement has a reduced ability of etching the smear layer and exposing the collagen fibrils or endogenous enzymes in the underlying dentine to CHX can exert its action [19]. This result agreed with these studies [20,21].

5.25% NaOCl irrigation of the post space resulted in the lowest mean bond strength without significant difference from the control group. This adverse influence of NaOCl might result from that; NaOCl is a pro-oxidant agent which inhibits the resin cement polymerization at the adhesive interface [22]. In addition, NaOCl alone cannot remove the smear layer effectively, leaving blocked dentinal tubules that reduce the resin cement infiltration [23].

This result agreed with these studies [16,24]. While in conflict with the results of Zhang, et al. [25], who reported that NaOCL irrigation increased the bonding strength of the fiber post looted by self-adhesive cement; however, this different result might be attributed to the lower concentration of NaOCl (2.5%) and less irrigation time (30 sec).

Although the efficacy of PUI in the removal of bacteria is well identified, its influence on the bonding ability of radicular dentine to the fiber post is not known. According to the results of this study, the bond strength did not increase by ultrasonic activation of the tested irrigant solutions; therefore, the second part of the null hypothesis cannot be rejected. These results agreed with Gu, et al. [26], who reported that the ultrasonic activation of 5.25% NaOCl or 0.9% saline solutions did not enhance the removal of smear layer, open dentinal tubules or improve the fiber post bonding strength.

In our study, the bond strength values of the apical regions were significantly higher than the coronal regions of all groups. This result was in agreement with these studies [27,28], which reported greater bonding strength at the apical region of the fiber post. In contrast, Amižić, et al. [29] observed greater bond strength values in the coronal part than apically; they attributed their results to the greater tubule density in the coronal part than the apical part; however, the greater bond strength at the apical area appeared to be associated more to the solid dentine area than to the dentine tubules density [27]. Also, the fiber post is in close contact with the dentinal walls in the apical region, which produce a locking area; therefore, the fiber post retention in this area depends on the adhesive bond and mechanical friction [1].

The analysis of the failure mode of all specimens revealed that the mixed adhesive failure was the predominant failure mode. In SH1 and SH2 groups, the predominant failure mode was the adhesive failure between the resin cement and dentine, which might indicate the adverse effect of the NaOCl on the bond between the radicular dentine and the resin cement. In contrast, the ET1 and ET2 groups revealed the least percentage of adhesive failure between the resin cement and dentine, indicating improved adhesion between the dentine and the resin cement.

CONCLUSIONS

- ✓ 17% EDTA post space irrigation significantly improved the bond strength of fiber post cemented with self-adhesive cement, while 5.25% NaOCL irrigation resulted in a non-significant reduction of bond strength.
- ✓ PUI had a non-significant effect on the bond strength of the fiber post.
- ✓ The highest bond strength was observed in the apical region of the post space.

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