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Push-out bond strength of a new post system after various post space treatments

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To assess the effect of post-space treatment with chelating agents on the push-out bond-strength of a glass fiber post-system. Forty-eight human teeth were decoronated. The roots were prepared to size 40 and obturated. The post-spaces were prepared with Peeso-Reamer drills. The post-spaces were irrigated with (i) NaOCl and EDTA with chlorhexidine (QMix), (ii) NaOCl and EDTA, (iii) NaOCl and Citric acid, (iv) NaOCl and saline as a control group. i-TFC glass fiber posts were then luted with i-TFC bond system. The samples were horizontally sectioned. The displacement resistance was measured. Push-out bond-strength (MPa) was calculated. Data were analyzed. NaOCl/QMix group showed highest values to dentine whereas NaOCl/Citric acid group showed lowest values. i-TFC post-system demonstrated equal bond strength values when post-space treated with either NaOCl/EDTA or NaOCl/Saline. It can be concluded that post-space could be treated with NaOCl and QMix in order to increase adhesion of i-TFC post-system to root-dentine.

Keywords: Citric acid, EDTA, i-TFC post, Push-out, QMix

INTRODUCTION

Endodontically treated teeth with limited residual tooth structure are commonly restored with a post and core[1]. The use of fiber-reinforced posts is a widely accepted because of an elastic modulus similar to that of dentine[2], and an ability to be bonded to dentin using an adhesive technique[3]. To improve the retention of the composite core to post and tooth, prefabricated fiber posts are cemented with adhesives and composite resin luting cements to dentin[4]. Several variables may affect the quality of adhesion at the dentine-cement-post interfaces: the action of irrigant solutions such as sodium hypochlorite (NaOCl), hydrogen peroxide (H_2O_2) and ethylenediaminetetraacetic acid (EDTA), the type of agent used to condition the substrate; the polymerization stress of resin cement; and the chemical and physical properties of the posts[5,6].

During the preparation of the post space, drills create a new smear layer that is rich in sealer and gutta-percha remnants[7]. The removal of the smear layer, which contains microorganisms, infectious dentin, canal sealer remnants, and which can influence the polymerization of resin luting cements, is essential to the bonding of post to dentin with resin[4,8]. Chemical agents such as NaOCl, H_2O_2, EDTA, chlorhexidine digluconate (CHX), citric acid, orthophosphoric acid (H_3PO_4), and their combinations are used to increase the micromechanical retention of the cement by removing the smear layer. As a result, the cement can penetrate into the dentinal tubules[4,8-10]. The most irrigant used is sodium hypochlorite because of its good tissue dissolving[11] and effective antimicrobial capabilities[12]. Decalcifying solutions such as EDTA and citric acid have been reported to be suitable to remove the smear layer[13]. Recently, QMix (Dentsply Tulsa Dental, Tulsa, OK, USA) is an endodontic irrigant for smear layer removal with added antimicrobial agents, has been developed. It contains EDTA, CHX and a detergent. QMix is a clear solution ready to use with no chairside mixing[14].

A glass fiber-reinforced epoxy i-TFC Post system (i-TFC Post, Sun Medical) has been recently introduced. This system includes both a sleeve made of braided fibers and a post system that can be cut and shaped using burs according to the anatomy of the post space. According to the manufacturer, both the post space and the sleeve should be filled with resin cement during restorative procedures. To date, no study has determined the effect of different root canal surface treatments on the push-out bond strength of an i-TFC post system. Therefore, the aim of this study was to evaluate the effect of post-space treatment with various chelating agents on the push-out bond strength of a new glass fiber post system.

MATERIALS AND METHODS

Forty-eight recently extracted single-rooted human roots of similar size and shape were selected. Crown of each tooth were sectioned at the buccal cement-enamel junction using a high-speed diamond saw (Isomet, Beuhler, Lake Bluff, IL, USA) with water-spray cooling. The root canals were prepared with K-files (Mani, Tochigi, Japan) using the step-back technique. The apical portion was enlarged to a No. 45 master file. The coronal portion of each canal was shaped with sizes 50-55-60 K-files. The root canals were irrigated with 1 mL of 1% NaOCl preceding the use of each instrument and

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then dried with absorbent paper points. The prepared root canals were filled with gutta-percha cones (Diadent Group, Seoul, Korea) and AH Plus sealer (Dentsply, Maillefer) by lateral condensation technique.

Filled roots were incubated at 37°C for 1 week under 100% humid conditions. The post spaces were prepared with Peeso Reamer drills #1 through #4 (Mani). To preserve the apical seal, at least 5 mm of the root fillings was retained at the apical level. The samples were then randomly divided into 4 groups (n=12) according to the chemical irrigant used:

Group 1; 5 mL of 5.25% NaOCl (Caglayan Kimya, Turkey) for 60 s, followed by a final flush with 5 mL of QMix (Dentsply) solution for 90 s.

Group 2; 5 mL of 5.25% NaOCl for 60 s, followed by a final flush with 5 mL of 17% EDTA solution for 90 s.

Group 3; 5 mL of 5.25% NaOCl for 60 s, followed by a final flush with 5 mL of 10% Citric acid solution for 90 s.

Group 4; 5 mL of 5.25% NaOCl for 60 s, followed by a final flush with 5 mL of 0.9% saline solution for 90 s.

After application of the irrigating solutions, the root canals were rinsed with distilled water and excess moisture was removed absorbent paper points. A glass fiber-reinforced epoxy post system (i-TFC Post, Sun Medical) was used. Compositions of the i-TFC post system used in the present study are listed in Table 1. i-TFC, fiber post was cut using diamond disk because the product was 45 mm. i-TFC bond was applied to the post space wall with a bond-brush for 20 s. Excess bond solution was removed with paper points, and the bond was gently air dried for 5–10 s. i-TFC optical fiber posts were then luted with i-TFC post resin (Sun Medical) according to the manufacturer's recommendations. Light curing was performed through the posts for 30 s using a conventional light curing unit (600 mW/cm^2 output; Hilux Ultra Plus, Benlioglu Dental, Ankara, Turkey). Then, the specimens were stored at 37°C and 100% humidity for 1 week.

After 1 week, the specimens were attached to the arm of a low speed saw (Isomet, Buehler) and sectioned perpendicular to the long axis under water cooling. Three sections, each 1.0±0.1 mm thick, were obtained from the coronal, middle and apical parts of the each root. The thickness of each specimen was measured and recorded by a digital caliper with an accuracy of 0.01 mm. The displacement resistance was measured using a Universal Testing Machine at a crosshead speed of 1 mm/min. Push-out bond strength (MPa) was calculated. Data were subjected to statistically analysis with two-way ANOVA and Tukey HDS test (α=0.05).

RESULTS

The mean of the push-out bond strength values (MPa) and standard deviations are in Table 2. Statistical analysis displayed that both the various post space treatments used and the section level (root thirds) significantly affected the bond strength values (p=0.0001). The interaction between these two factors was not significant (p=0.342). For the factor various post space treatments, significant difference was found groups (p=0.0001). 5.25% NaOCl/QMix (6.75±3.20MPa) treated group displayed highest push-out bond strength values to dentine. However no significant difference was found between the 5.25% NaOCl/QMix group and 5.25% NaOCl/EDTA group (p=0.67). 5.25% NaOCl/10% Citric acid (4.46±2.57 MPa) group showed lowest push-out values, but no significant difference was found between the 5.25% NaOCl/10% Citric acid group and 5.25% NaOCl/Saline group (p=0.87). i-TFC post system

Table 1 Compositions of the i-TFC post system used in the present study

i-TFC post system	Composition
Core resin	Bis-MPEPP, PDMA, UDMA, PI Barium Silica Glass, Colloidal Silica (86 wt%, 70 vol%)
Post resin	Bis-MPEPP, PDMA, TEGDMA, UDMA, PI Barium Silica Glass, Colloidal Silica (65 wt%, 44 vol%)
Bond	Bond: 4-META, Bis-MPEPP, PI, Acetone, Water, Silica (10 wt%) Bond brushes: Sodyum p-toluenesulfinate, Aromatic amine
Sleeve	78% Glass fiber 22% UDMA-based matrix resin
Optical fiber post	72% Glass fiber 18% UDMA-based matrix resin 10% optical fiber

Bis-MPEPP: 2,2-Bis[4-(Methacryloxyethoxy)phenyl]propane, PDMA: Phenylene dimethacrylate, TEGDMA: Triethyleneglycoledimethacrylate, UDMA: Urethane dimethacrylate, 4-META: 4-Methacryloyloxy trimellitate anhydride, PI: Photo initiator

Table 2 Mean push-out bond strengths (MPa)±SD values for experimental groups according to the root thirds

Group	Apical	Middle	Coronal	Total
NaOCl/QMix	5.92±3.01	6.22±2.24	8.10±3.76	6.75±3.20 a*
NaOCl/EDTA	5.65±2.17	5.72±2.44	5.62±2.53	5.66±2.36 ab
NaOCl/Citric acid	4.34±2.84	3.79±2.26	5.25±2.47	4.46±2.57 c
NaOCl/Saline	4.00±2.06	4.82±2.88	5.54±2.15	4.80±2.45 bc
Total	5.00±2.67 1	5.13±2.61 1	6.13±2.98 2	—

*Different lowercase letters show statistical significant differences with amongst the various post space treatments. Different superscripted numbers indicate significant differences with regard to the factor section level.

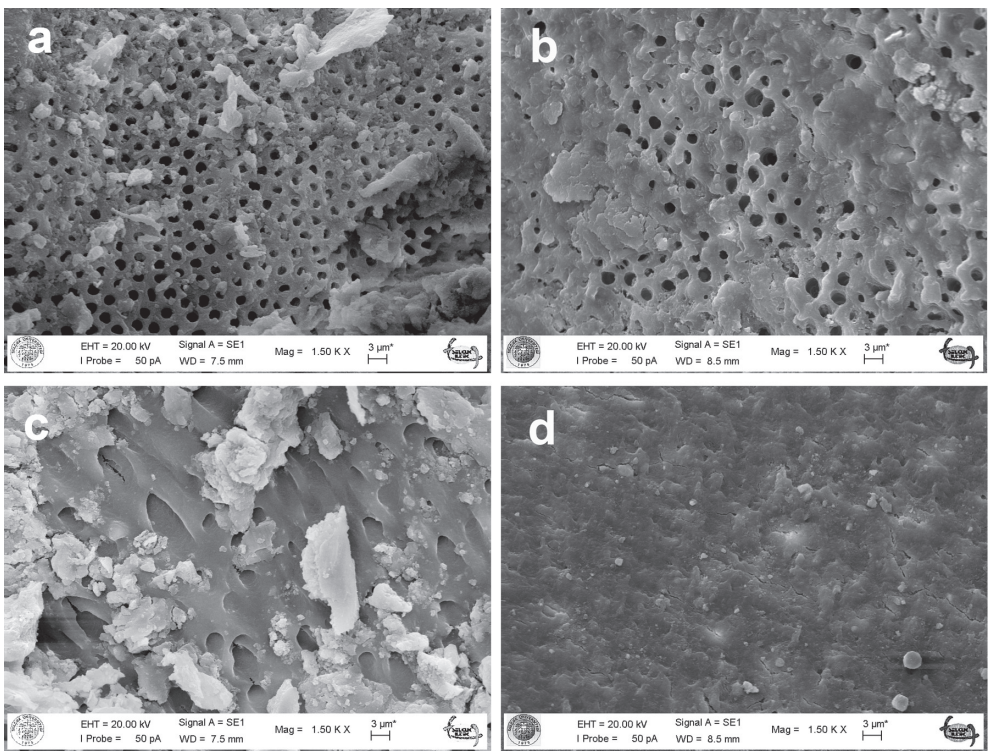

Fig. 1 Scaning electron microscopy of root canal wall exposed to a) NaOCl/Qmix, b) NaOCl/EDTA, c) NaOCl/Citric acid and d) NaOCl/Saline.

Table 3 Mode failure percentages with respect to post space irrigation protocols

Mode of failure	NaOCl/QMix	NaOCl/EDTA	NaOCl/Citric acid	NaOCl/Saline
Adhesive between dentin-cement	25	33.3	50	50
Cohesive within cement	—	—	—	—
Mixed failure	75	66.7	50	50

demonstrated equal bond strength values when post space treated with either 5.25% NaOCl/17% EDTA (5.66±2.36 MPa) or 5.25% NaOCl/Saline (4.80±2.45 MPa) (p=0.20).

For the root level, the coronal level of the root had significantly higher bond strength values when compared with the middle and apical level (p=0.005) (Table 2).

In the control group (group 4, NaOCl/Saline) a

thick smear layer was observed throughout the root canal dentine walls and lacking any opening of dentinal tubules. In group 3 (5.25% NaOCl/10% Citric acid) and group 2 (5.25% NaOCl/17% EDTA), the smear layer was partially removed. In the group 1 (5.25% NaOCl/QMix) the smear layer was complete removed (Fig. 1).

The frequency of each type of bond failure mode is given in Table 3. The most common failure mode was mixed, followed by adhesive failure between the dentin and resin cement and cohesive failure in the resin cement. No cohesive failures were found in the post or within the dentin.

DISCUSSION

The adhesive bonding of fiber posts and resin luting systems to root dentine is based on the micromechanical retention formed by demineralized dentine surface and resin tag formation[15]. After post space preparation, cleaning the surfaces of root canal walls is a crucial procedure for optimal post retention. The presence of smear layer and debris along the post space canal walls can impede the optimal dentine adhesion in fiber post bonding[16]. In this study, the adhesion of a new i-TFC glass fiber post after various post space treatments to coronal, middle, and apical thirds of root canal dentine was determined using a push-out test. Push-out tests result in a shear stress at the interface between dentine and cement[15] and are comparable with the stress under clinical situation. The push-out test is a more reliable method for determining bond strengths between fiber posts and post space dentine because of the high number of premature failures occurring during specimen preparation and large data distribution spread associated with microtensile testing[5].

In the present study, bonding of i-TFC post to root canal dentin was affected differently by the various post space treatments. The use of 5.25% NaOCl/QMix irrigation groups showed the highest bond strength value. QMix is a designed to be used as a final rinse for 60–90 s in place of 17% EDTA, yet it causes less demineralization of intact dentin collagen than EDTA[17]. Therefore, in this study, the canals were treated with QMix for 90 s, followed by 5.25% NaOCl for 60 s. According to the manufacturer's, QMix is a proprietary blend of 2% CHX, EDTA and surfactant that completely removes the smear layer and smear plugs, while disinfecting at the same time. Moreover, QMix contains a detergent that decreases surface tension and increases wet ability in solutions to potentially allow better intracanal delivery[18]. Hence, its wet ability which could improve post adhesion to root dentin with resin cements[19]. In the present study, no significant difference was found between the 5.25% NaOCl/QMix group and 5.25% NaOCl/EDTA group. Previous studies reported that the QMix was as effective as 17% EDTA in removing canal wall smear layers after the use of 5.25% NaOCl as the initial rinse[14,20]. EDTA solution has a relatively low surface tension, which might improve the wettability[21]. This is supported by the SEM image of 5.25% NaOCl/QMix and 5.25% NaOCl/EDTA group showing open dentinal tubules with slight erosion of the orifices and the efficacy of QMix on removing the smear layer (Figs. 1 a and b)

On the other hand, in the present study, 5.25% NaOCl/Citric acid treated group showed lowest push-out bond strength values; however no significant difference was found between the 5.25% NaOCl/Saline treated group. The SEM image of citric acid followed by NaOCl treatment showing partially removed the smear layer on root canals (Fig. 1c). The presence of smear layer in along the post space canal walls in 5.25% NaOCl/Citric acid treated group can impede the optimal dentine adhesion in fiber post. The adhesive bonding of fiber posts and resin luting systems to root dentine is based on the chemical interactions between monomeric acidic groups and hyroxyapatite and on micromechanical retention[22]. Moreover for i-TFC post system, it was claimed by the manufacturer to have bond liquid dissolves accelerators impregnated on Bond-brushes. i-TFC Bond performs a dual cure and hardened tightly with post resin by the light through the optical fiber.

Some studies have demonstrated higher bond strengths in the apical third than in the other parts of the root canal[23-25]. D'Arcangelo *et al.*[26] reported that the coronal regions of the canals were significantly higher bond strengths, whereas other reports suggested that root canal region does not influence adhesion of post to canal dentine[27]. In the present study, the highest bond strength values were found in the coronal third for all experimental groups. According to a previous study[28] as the number of dentine tubules decreases moving from the cervical to the apical third of the post space dentine the difference in the tubule density may explain why the strongest adhesion occurred in the most coronal sections. The most likely explanation for the higher resistance to post in the coronal region of the root canal could be the decreasing effectiveness of light curing at greater distances from the light source. Moreover, the coronal portion of the canal is making it easier thoroughly apply the adhesive agents[29,30]. A reduction of strength in middle and apical thirds may also be related to the more difficult distribution of resin cement[29,30] or to traces of gutta-percha and endodontic sealer that may remain in these thirds after post space preparation.

This study revealed that post space could be trated with 5.25% NaOCl and QMix in order to increase adhesion of i-TFC post system to root dentine.

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