

Effect of Post Space Irrigation using Novel Irrigant: SmearOFF (containing Chlorhexidine and EDTA) on the Push-out Bond Strength of Fiber Posts luted with Self-adhesive Resin Cement

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ABSTRACT

Aim: To make a comparative evaluation of the effect of different post space irrigation procedures on the push-out bond strength of prefabricated fiber posts luted with self-adhesive resin cement in different root thirds (coronal, middle, and apical).

Materials and methods: Sixty freshly extracted single-rooted teeth were selected, and after root canal preparation and obturation, standardized post spaces were prepared. Teeth were then randomly divided into four groups (n = 15), according to the different post space irrigants used: group I—distilled water (control); group II—17% ethylenediaminetetracetic acid (EDTA) + 2.5% sodium hypochlorite (NaOCl); group III—99% ethanol; group IV—SmearOFF. All solutions were maintained in the root canals for 60 seconds and dried with paper points. Prefabricated fiber posts were luted using the self-adhesive resin cement. The push-out test was carried out by applying a load using Instron Universal Testing Machine.

Results: The results of the analysis of variance (ANOVA) and the *post hoc* Bonferroni tests revealed that the push-out bond strength was significantly affected by the different post space irrigants ($p < 0.001$). However, no significant difference in push-out bond strength was attained with reference to the different locations inside the canal (i.e., coronal, middle, and apical) ($p > 0.05$).

Conclusion: Pretreatment of the post space using 99% ethanol resulted in highest bond strength with respect to prefabricated fiber posts luted with self-adhesive resin cement. The push-out bond strengths exhibited by both, the newly launched irrigant: SmearOFF and the combination of EDTA + NaOCl, were comparable.

Clinical significance: Irrigation of post space after mechanical post space preparation is the central key to remove smear layer, open dentinal tubules along with achieving superior bond strength of fiber posts cemented with a self-adhesive resin cement to root dentin.

Keywords: Ethanol, Fiber post, Irrigation, Push-out, SmearOFF.

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INTRODUCTION

Patients who have had endodontic treatment frequently present with problems, such as extensive coronal damage from caries or trauma, thus requiring intraradicular retentive strategies to stabilize the restoration as well as restore the previous esthetic form and functionality of the teeth.¹ Prefabricated fiber posts in combination with resin cements have been preferred to restore endodontically treated teeth as an alternative to prefabricated metal posts or custom cast post.²⁻⁴ Their main advantage is the elastic modulus which is very close to that of dentin, thus resulting in a balanced stress distribution pattern and reduced possibility of vertical root fractures. However, luting of posts to inter-radicular dentin can pose a challenge owing to the high C-factor inside the canal, limited access, and moisture control.⁵ The weakest link of the whole tooth-posts-restoration system may be identified in the adhesion between the substratum and the resinous cements. Adhesion grossly depends on removal of the smear layer, which interferes with the formation resin dentin interdiffusion zone;⁶ also bond degradation may occur due to water absorption or by proteolytic degradation (collagenolysis) of the hybrid layer, by action of matrix metalloproteinases (MMPs).⁷

Various post space treatment strategies have been explored in order to preserve the resin-dentin adhesion. Irrigation with EDTA in combination with NaOCl has proven to efficiently remove the smear layer. The chelating property of EDTA removes the inorganic component, and the tissue-dissolving property of NaOCl eliminates the organic component.⁸ Chlorhexidine digluconate (CHX) is a potent antiseptic with a broad-spectrum antimicrobial activity and substantivity. It is also known to

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prevent collagenolysis by inhibition of the MMPs and thus secure the resin–dentin bond.⁹ Another pretreatment strategy is the ethanol wet bonding technique. Ethanol coaxes hydrophobic monomers into a demineralized collagen matrix without sacrificing any additional matrix shrinkage.¹⁰ SmearOFF is a novel irrigant having synergistic combination of both EDTA and chlorhexidine. So, it not only aids in removal of smear layer but also inhibits the MMP-related bond degradation. To the authors' best knowledge, no study has evaluated the effect of this irrigant on the bond strength of prefabricated fiber posts to canal dentin.

Furthermore, several studies have appraised the use of self-adhesive resin cement to lute prefabricated fiber posts to dentin. It does not require tooth surface pretreatment for adhesion, as it is based on the chemical interactions between monomeric acidic groups and hydroxyapatite, and on micromechanical retention.^{11,12} However, less literature is available about the effects of the pretreatment protocol prior post placement using self-adhesive resin cements.

Therefore, the aim of the present study was to assess the effect of different post space irrigating agents on the push-out bond strength of prefabricated fiber posts luted with self-adhesive resin cement in different root thirds (coronal, middle, and apical).

MATERIALS AND METHODS

Freshly extracted intact human mandibular premolars (for orthodontic purpose) without caries, with anatomically similar roots were selected. The teeth were examined with a stereomicroscope under 10× magnification to detect craze lines or cracks which were excluded from the study. Performing the above procedure resulted in 60 specimens. The teeth were stored in 0.1% thymol solution, and were decoronated at the cemento enamel junction with a diamond-coated saw (Isomet 2000; Buehler Ltd., Lake Bluff, Illinois, USA). The roots were adjusted to 16 mm in length and the working length was established 1 mm short of the apex. All the root canals were instrumented using ProTaper Universal rotary instruments (Dentsply Maillefer, Ballaigues, Switzerland), according to the manufacturer's recommendation. The master apical instrument was the ProTaper Universal F3. Then, 5 mL of 2.5% NaOCl was used for irrigation between each instrumentation with a final rinse of 2 mL 17% aqueous EDTA for 1 minute, followed by 5 mL of 2.5% NaOCl. Each root canal was dried with paper points (Protaper® Universal Paper Points) size F3 matching the final finishing file, and obturated with gutta-percha using cold lateral condensation technique and AH Plus sealer (DeTrey Dentsply, York, Pennsylvania, USA). The teeth were stored at 37°C and

100% humidity for 7 days to allow for the setting of the sealer. All the root canals were enlarged with a #2 Unicore Drill (Ultradent, South Jordan, Utah, USA), using a low-hand piece, to a depth of 10 mm. During preparation of the canal, 5 mm of the endodontic filling was left at the apex of each canal. All samples received a final rinse with 5 mL of distilled water, and the excess was removed using paper points (Protaper® Universal Paper Points).

Teeth were then randomly divided into four groups (n = 15):

1. Group I (control): The roots were irrigated with 2 mL distilled water.
2. Group II: The roots were irrigated with 2 mL of 17% aqueous EDTA over 1 minute, rinsed out by distilled water, and then irrigated with 2 mL of 2.5% NaOCl over 15 seconds. Final rinse was done with distilled water.
3. Group III: The roots were irrigated with 2 mL of 99% ethanol over 1 minute.
4. Group IV: The roots were irrigated with 2 mL of SmearOFF solution (VistaDental) over 1 minute.

All solutions were maintained in the root canals for 60 seconds and dried with paper points. Fiber post placement was done using RelyX U200 (3M ESPE), a self-adhesive resin cement. After excess was removed, light curing was performed using light-emitting diode unit (Bluephase polywave LED, Ivoclar Vivadent) according to manufacturer's instructions. All specimens were maintained in 100% humidity, for 24 hours, at 37°C. Each root was then cut horizontally to the longitudinal axis using a low-speed diamond-coated saw (Isomet 2000, Buehler Ltd.) under water cooling. Three slices were prepared at a thickness of 2 mm in the coronal, middle, and apical third of each root, which were taken respectively, 1, 5, and 8 mm from the cemento enamel junction.

Mechanical Testing

The push-out test was carried out by applying a load using Instron Universal Testing Machine (Zwick, Germany), at a cross-head speed of 0.5 mm/min in the apex in the direction of the crown until the fiber post resin cement segment was dislodged from the root slice. A cylindrical plunger was used to dislodge with 1, 0.7, and 0.4 mm diameters to the coronal, middle, and apical thirds respectively.

Statistical Analysis

Descriptive statistics were expressed as means and standard deviation (SD) for each group. The effect of different post space irrigation procedures on the push-out bond strength of the posts was assessed by comparison

Table 1: Comparison of the push-out bond strength of the posts after various irrigation procedures in the coronal, middle, and apical third of the canal

Push-out bond strength	Coronal	Middle	Apical
	Mean ± SD	Mean ± SD	Mean ± SD
Group I	4.89 ± 0.41	4.96 ± 0.55	4.61 ± 0.57
Group II	5.95 ± 0.48	5.94 ± 0.33	6.06 ± 0.37
Group III	7.24 ± 0.24	7.11 ± 0.30	7.08 ± 0.22
Group IV	6.05 ± 0.30	6.02 ± 0.38	6.00 ± 0.37
p-value (one-way ANOVA)	<0.001*	<0.001*	<0.001*

*p ≤ 0.05 is statistically significant

Table 2: Comparison of push-out bond strength of posts after post space irrigation with four different irrigation protocols

Push-out bond strength	Group I	Group II	Group III	Group IV
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Coronal	4.89 ± 0.41	5.95 ± 0.48	7.24 ± 0.24	6.05 ± 0.30
Middle	4.96 ± 0.55	5.94 ± 0.33	7.11 ± 0.30	6.02 ± 0.38
Apical	4.61 ± 0.57	6.06 ± 0.37	7.08 ± 0.22	6.00 ± 0.37
p-value* (one-way ANOVA)	0.152	0.659	0.186	0.938

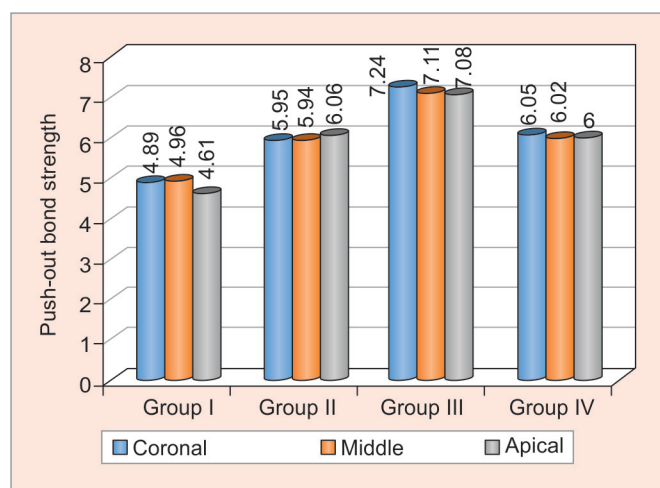
*p ≤ 0.05 is statistically significant

of groups using ANOVA test with *post hoc* Bonferroni test (Tables 1 and 2). In the above tests, p ≤ 0.05 was taken to be statistically significant. All analyses were performed using Statistical Package for the Social Sciences software, version 17.

RESULTS

- The push-out bond strength was significantly affected by the different irrigants (p < 0.001)
- However, no significant difference in push-out bond strength was attained with reference to the different locations inside the canal (i.e., coronal, middle, and apical) (p > 0.05)
- Treating the post space with ethanol (group III) showed the highest bond strength regardless of the location inside the canal
- No significant difference in push-out bond strength was noted when post space was treated with the combination of 17% aqueous EDTA and 2.5% NaOCl (Group II) or SmearOFF (Group IV) (p = 1.000).

The comparison of push-out bond strength of posts after post space irrigation with four different irrigation protocols has been represented in Graph 1.



Graph 1: Comparison of push-out bond strength of posts after post space irrigation with four different irrigation protocols

DISCUSSION

The results of the study revealed that the bond strength of fiber posts inside the root canal differed significantly between different pretreatment irrigating agents. In general, improvements in bond strength values (MPa) were found in the following order: ethanol > (17% EDTA + 2.5% NaOCl) = SmearOFF > distilled water groups.

Highest bond strength was achieved by group III (99% ethanol). This could be attributed to ethanol’s “water chasing” ability. It replaces the water in the dentin, so the hydrophobic monomers are able to penetrate the dentin and form a more stable hybrid layer.¹³ Previous studies have also indicated that insufficient moisture control in the depth of the root canal could be compensated by ethanol wet bonding. It might increase the resin uptake and sealing of the collagen matrix and probably also increase the degree of conversion of hydrophilic adhesives.¹⁰ The results of this study are in accordance with the study by Bitter et al,¹⁴ which concluded that ethanol significantly increased bond strength in case of the etch-and-rinse adhesive approach and a self-adhesive resin cement inside the root canal.

The use of 17% aqueous EDTA in conjunction with 2.5% NaOCl, as a post space irrigant has showed better bond strength values as compared with that of the control group in the present study. Ethylenediaminetetracetic acid acts as a calcium chelator that dissolves the smear layer.⁷ Also, the relatively low surface tension of aqueous EDTA might improve the dentin wettability.¹⁵ Sodium hypochlorite dissolves the organic components (mainly collagens) of the smear layer, and increases the penetration monomers into the demineralized dentin structure. However, on application of 5% NaOCl to dentin’s surface, it breaks down to sodium chloride and oxygen. The released oxygen causes strong inhibition of the interfacial polymerization of resin bonding materials, resulting in decreased bond strength.¹⁶ However, a study by Arisu et al¹⁷ concluded that increased dentin bond strengths were demonstrated when post space irrigation was

performed with NaOCl and EDTA, with use of self-etching adhesives, as compared with pretreatment with NaOCl alone and diode laser.

SmearOFF is a recently introduced irrigant that contains a synergistic combination of both EDTA and CHX. The manufacturer claims that EDTA enhances the demineralization of radicular dentin due to its chelating effect while disinfecting the canal at the same time due to presence of CHX. Matrix metalloproteinases and cysteine cathepsins present in mineralized dentin contribute to collagen fibrils' degradation, hindering the *quasi*-static mechanical properties of the collagen matrix. Therefore, the use of MMP inhibitors, such as chlorhexidine, prior to the bonding appears to be a rational step for extending the longevity of the hybrid layer.¹⁰ Yet, in the present study, comparable bond strengths were recorded by group II (17% EDTA + 2.5% NaOCl) and group IV (SmearOFF). Hence, it can be said that the bond strength achieved in group IV (SmearOFF) can be mainly attributed to EDTA's chelating property, which leads to enhanced smear layer removal, rather than the MMP inhibition by CHX. Also, previous studies by Bitter et al¹⁴ and Cecchin et al⁶ have concluded that irrigation of the post space by chlorhexidine displayed results comparable to that of the control group. In addition, Lindblad et al¹⁸ investigated the efficacy of chlorhexidine in increasing the resin cement bond strength and indicated that no negative effects were observed.

The bonding mechanism of adhesive systems to root canal dentin is based on hybridization of the demineralized surface and on resin tags and lateral branch formation.¹⁹ Tubule density and diameter of the tubules decrease in the apical direction, which may influence the micromechanical bonding mechanism of the adhesive systems.²⁰ Other reasons for variable bond strengths in different root regions have been stated to be technical sensitivity, the difficulty of applying an adhesive in a narrow post space, and limited light transmission to the apical region.²¹ In the past decade, self-adhesive resin cements were introduced to provide easier clinical application compared with regular resin cements. RelyX U200 (3M ESPE) is the most widely used self-adhesive resin cement. Its adhesive properties have been based on acid monomers that demineralize and simultaneously infiltrate by methacrylate monomers of the tooth substrate, creating micromechanical retention and chemical bonding to hydroxyapatite.²² The results of this study also indicate that different root regions (coronal, middle, apical) exhibited comparable push-out bond strengths; this could be attributed to the aforementioned properties of the self-adhesive resin cement. However, future studies must be conducted to examine the long-term effects of different post space irrigation procedures on

the bond strength of self-adhesive resin cement to inter-radicular dentin.

CONCLUSION

Within the limitations of this *in vitro* study, it can be concluded that pretreatment of the post space using 99% ethanol can be recommended as a final rinse prior to luting of prefabricated fiber posts. SmearOFF can be used as a viable single solution alternative to use the combination of EDTA + NaOCl with respect to post space irrigation.

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