Effect of Intracanal Medicaments on Pull-Out Bond Strength of Fiber Post Cemented with a Self-Adhesive System

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Abstract

Objectives This study aimed to assess the effect of four intracanal medicaments on pull-out bond strength of fiber posts.

Materials and Methods A total of 65 single-rooted, single-canal teeth were selected and decoronated. Root canals were prepared and after rinsing were randomly divided into five groups (n = 13). G_1: calcium hydroxide (CH), $G_{2:}$ CH plus chlorhexidine (CH+CHX), G_3: triple antibiotic paste (TAP), G_4: double antibiotic paste (DAP) were applied in the canals in the four groups. The control group (G_5) received no medicament. After 4 weeks, the medicaments were rinsed off and the canals were filled with gutta-percha. Post space was then prepared in root canals for the placement of glass fiber posts and self-adhesive cement (Panavia F2). After cementation, they were subjected to pull-out bond strength test.

Statistical Analysis Data were statistically analyzed using one-way analysis of variance and Tukey test.

Results The pull-out bond strength values were significantly different in the groups ($p < 0.001$). The highest values of bond strength were seen in G_2, G_1, and G_3 (359.97 ± 81.26, 333.79 ± 98.96, 309.27 ± 78.07), respectively. There was no significant difference between G_4 and G_5 ($p = 0.75$).

Conclusion The results showed that CH, CH+CHX, and TAP enhanced the pull-out bond strength of fiber post to root canal wall as compared to the control group.

Keywords
- pull-out bond strength
- double antibiotic paste
- triple antibiotic paste
- calcium hydroxide
- chlorhexidine
- fiber post

Introduction

Microorganisms are the main cause of pulp and periapical disease.[1] Thus, the main focus of endodontic treatment is efficient elimination of microorganisms from the pulp and periapical region.[2] Root canals have a complex anatomy and have inaccessible areas. Thus, root canal preparation should include a combination of mechanical and chemical preparations to effectively eliminate the microorganisms.[3]

Calcium hydroxide (CH) is among the most commonly used intracanal medicaments and extensively used in endodontic treatment of teeth due to its alkaline pH, antibacterial effect, and induction of hard tissue formation.[4] CH can be used for short-term or long-term.[5] In long-term use of CH, it may decrease the strength of root dentin and increase the risk of tooth fracture.[6]

On the other hand, it has been shown that application of a combination of CH and chlorhexidine (CHX) has better

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antimicrobial activity than CH alone and has optimal biocompatibility without adversely affecting the seal of root canal filling.[7]

Triple antibiotic paste (TAP) is another commonly used intracanal medicament and is composed of ciprofloxacin, metronidazole, and minocycline.[8] Due to its antimicrobial properties and enhancing the development of dentin–pulp complex, TAP is often used in open apex teeth. It can eliminate microorganisms from the most distant areas in the apical region.[9] However, long-term use of TAP has a drawback of tooth discoloration due to the presence of minocycline in its composition.[10] Double antibiotic paste (DAP) was later introduced, which does not contain minocycline. It possesses the optimal properties of TAP without causing discoloration.[11,12] It has been shown that both medicaments appear to have promise as alternative for CH therapy in cases in which symptoms cannot be easily subsided.[13,14]

Teeth undergoing root canal treatment have often lost a large part of their structure, and coronal restoration of these teeth often requires retention provided by intracanal posts such as fiber posts.[15] A previous study has shown that intracanal medicaments (CH, TAP, and DAP) negatively affect the dentin structure,[16] which may have an influence on the post-endodontic treatment. On the other hand, there are conflicting results about the effect of CH, CHX, and DAP on bond strength of fiber post to dentin.[17-21] Considering the controversial results, this study sought to assess the effect of intracanal medicaments on pull-out bond strength of glass fiber post (Reforpost, Angelus, Brazil) cemented with dual-cured resin (Panavia F2, Kuraray, Tokyo, Japan)) to root dentin to evaluate the possible effects of intracanal medicaments on root dentin. The null hypothesis was that CH, CH and CHX, DAP, and TAP have no adverse effect on pull-out bond strength of glass fiber post.

Materials and Methods

This ex-vivo, experimental study was conducted on 65 single canaled mandibular premolar teeth with straight roots and no restoration, cracks, caries or root resorption, extracted within the past 3 months for orthodontic treatment or periodontal disease. The teeth were immersed in 0.5% chloramine T solution for 1 week for disinfection and stored in saline at 37°C until the experiment.

Tooth Preparation

The teeth were decoronated using a diamond bur and high speed hand-piece (Apadana Tak, Tehran, Iran) under water coolant perpendicular to the longitudinal axis of the teeth such that the remaining root length was 14 mm. Next, #10 and #15 K files (Dentsply, Maillefer, Switzerland) were introduced into the canal to ensure patency and working length was measured. Root canals were then prepared with ProTaper Universal system up to F4 (Dentsply Maillefer; Ballaigues, Switzerland) 1 mm short of the apex according to the manufacturer's instructions. All canals were rinsed with 5.25% sodium hypochlorite. To remove the smear layer, 5.25% sodium hypochlorite and 17% ethylenediaminetetraacetic acid (MD-Cleanser; Biomed, Chungcheongbuk-do, Korea) were used each for 60 seconds. A final rinse with saline was also performed and the root canals were dried with paper point.

Application of Intracanal Medicament

The teeth were randomly divided into five groups (n = 13):

Group 1: CH was used in group 1 (GolchaDent, Tehran, Iran) as intracanal medicament. The CH powder was mixed with saline such that a creamy consistency was obtained. The paste was delivered into the canal using a #30 Lentulo spiral (Dentsply Maillefer, Tulsa, Oklahoma, United States). Excess material was removed by a moist cotton pellet from the coronal part of the root.

Group 2: A combination of CH and CHX gel (Periokin, Barcelona, Spain) was used with a creamy consistency and delivered into the canal using a Lentulo spiral as in group 1. Excess material was removed as mentioned before.

Group 3: TAP including ciprofloxacin (Alborzdaro, Gazvin, Iran), metronidazole (Alborzdaro, Gazvin, Iran), and minocycline (Minostad, STADA Arzneimittel GmbH, Wien, Austria) was used in group 3. Each tablet was milled in a mortar to obtain a powder. Then, equal amounts of the three powders were weighed by a digital scale (Zhejiang Yubang Weighing Apparatus, Zhejiang, China) and mixed. The mixture was mixed with saline and delivered into the canal as in groups 1 and 2.

Group 4: DAP including ciprofloxacin and metronidazole with equal amounts (by weight) was used in this group and delivered into the canal as in groups 1 and 2.

Group 5 (control group): No medicament was used in this group

To ensure coronal seal, the orifice was temporarily restored with Cavit (3M ESPE, Seefeld, Germany) in all experimental groups.

The four groups containing intracanal medicaments were incubated for 4 weeks at 37°C and 100% humidity.

Root Canal Filling

In the four groups containing medicaments, temporary restorative material was removed by a round bur and high speed hand-piece under copious water irrigation and the canals were rinsed with saline. Then, the canals were filled using #35 gutta-percha (AriaDent, Tehran, Iran) as master cone and #20 gutta-percha as accessory cones and AH26 sealer (Dentsply, Constanz, Germany) via lateral compaction technique. Then, 9 mm of gutta-percha was removed from the canal using #2 and #3 Gates Glidden drills such that 5 mm of gutta-percha remained in the apical region to maintain apical seal. The remaining canal space was rinsed with saline and dried with paper point. Excess sealer was removed. Radiographs were obtained to ensure the 5 mm gutta-percha for apical seal and the absence of gutta-percha and sealer on canal walls.

Intracanal Post Placement and Cementation

Panavia F2 dual-cured resin cement was used for the cementation of glass fiber posts. ED primer was applied on canal walls by a micro-brush for 30 seconds according to the manufacturer's instructions. After gentle air spray, excess material was removed by paper point from the canal orifice. Then, #1 glass fiber was chosen, marked at 9 mm length using an endometer and tried in the canal to ensure it reached the required length. Equal amounts of A and B pastes of Panavia F2 were mixed on a mixing pad and applied on the surface of fiber post such that it was covered with a thin layer of cement.

It was then introduced into the canal according to the manufacturer's instructions. The remaining length of post out of the canal was also maintained for load application. Light curing was performed for 20 seconds using Valo light curing unit (Ultradent, South Jordan, Utah, United States). To enhance gripping by the test fixture, a small amount of tray resin was used on the top of each post and then the teeth were immersed in saline and incubated in standard conditions for 24 hours.

To better simulate the clinical setting, root canals in the control group were also prepared and filled. Post-space was prepared thereafter and the post was cemented as explained above. The 4-week incubation was not performed for this group.

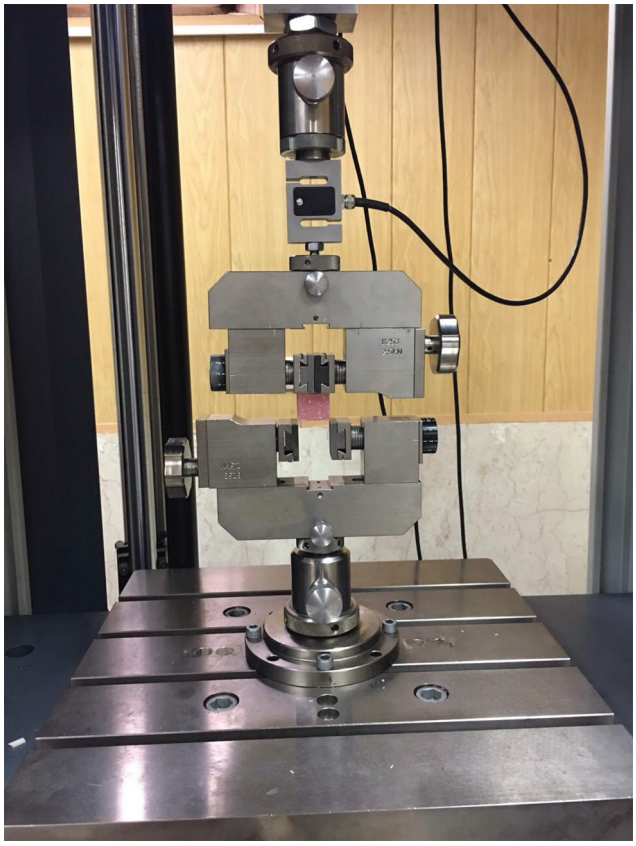

Fig. 1 Pull-out bond strength using universal testing machine.

Mounting of Teeth

A prefabricated metal mold was used to fix the teeth for load application. The mold was first coated with Vaseline and then auto-polymerizing acrylic resin was poured into each well of the mold measuring 2 × 2 × 3 cm. After reaching adequate consistency, each tooth was mounted in acrylic resin at the center of each well. After completion of setting time of acrylic resin, the two parts of the mold were separated for load application.

Pull-Out Test

The lower compartment was fixed to the jig of universal testing machine (Zwick/Roell, Ulm, Germany) from both sides. The external part of the post was connected to the upper compartment and load was applied at a crosshead speed of 2 mm/min (►**Fig. 1**). Maximum load causing dislodgement of post from the root canal wall was recorded in Newtons (N).

Statistical Analysis

Data were collected in SPSS software and analyzed using one-way analysis of variance (ANOVA). p-Value < 0.05 was considered statistically significant.

Results

Kolmogorov–Smirnov test and Shapiro–Wilk test indicated normal distribution of pull-put bond strength data (quantitative variable). ►**Table 1** shows the mean pull-out bond strength in the groups. One-way ANOVA showed a significant difference in pull-out bond strength of the groups (p < 0.001). The post hoc test revealed that the mean values of bond strength were significantly higher in CH group (p = 0.001), and CH + CHX group (p < 0.001) and TAP group

Table 1 Mean pull-out bond strength (N) in the groups

Intracanal medicaments	Mean	SD	Minimum	Maximum
Control	201.46	83.42	54.53	316.81
CH[a,b]	333.79	98.96	107.91	451.53
CH+CHX[a,b]	359.97	81.26	256.19	526.81
TAP[a]	309.27	78.07	200.15	483.49
DAP	239.82	58.96	116.14	313.64

Abbreviations: CH, calcium hydroxide; CHX, chlorhexidine; DAP, double antibiotic paste; SD, standard deviation; TAP, triple antibiotic paste.
[a]Indicates significant difference with control group.
[b]Indicates significant difference with DAP. There was no significant difference among other groups.

(p = 0.01) in comparison to control group.No significant difference was seen between the control and DAP in terms of pull-out bond strength (p = 0.75). Also, there was significant difference between DAP/CH and DAP/CH + CHX (p-value= 0.04 and 0.003, respectively). No difference has been found among other groups.

Discussion

Elimination of infection from the root canal system is challenging in endodontic treatment. Bacteria are mainly responsible for pulp and periapical disease.[22] Due to the complex anatomy of the root canal system and presence of inaccessible areas, a combination of mechanical (endodontic instruments) and chemical (root canal irrigating solutions and intracanal medicaments) methods has been suggested to eliminate microorganisms from the root canal system.[23] Thus, intracanal medicaments are used for their antimicrobial activity in the root canal system.[24] The medicaments might remain in the root canal for 1 to 4 weeks.[25,26] CH alone or in combination with CHX, TAP, and DAP is commonly used as intracanal medicaments.[27] However, their use is associated with some concerns regarding their effects on root dentin.[21] This is especially important for final restoration of tooth crown since endodontically treated teeth have often lost a large amount of tooth structure, and coronal restoration of these teeth requires retention, which is often provided by intracanal posts. Fiber posts are bonded to the canal wall via the use of adhesive systems. This bond may be affected if intracanal medicaments modify the structure of root dentin.[16,28] In this study, intracanal medicaments were removed using traditional needle irrigation as the most frequently used method. However, a study has shown that some of the intracanal medicaments such as TAP may have adverse effect on self-adhesive cements to root dentin.[21] On the other hand, recent studies have suggested XP Endofinisher (FKG Dentaire, La Chaux-de-Fonds, Switzerland) as an alternative irrigation method to remove intracanal medicaments effectively.[29,30] Thus, further research is needed to evaluate the effect of more efficient intracanal dressing removal technique on bond strength of fiber posts.

Previous studies have shown that the time of post cementation (immediate versus 7 days after the completion of root canal treatment) has no negative effect on fiber post retention using epoxy resin-based sealer.[31,32] Since the present study aimed to evaluate the sole effect of intracanal dressing on pull-out bond strength of cemented resin post, immediate post cementation was performed to reduce the possible effect of AH26 sealer as a confounding factor.

Pull-out test was performed in present study because in this test, load is applied along the longitudinal axis of the intracanal post and tooth. In this method, stress is better distributed and bond strength of post to root dentin can be more accurately measured. Therefore, pull-out test is superior when the objective is to measure the load required for removal of post along the longitudinal axis of the canal.[33]

Calcium hydroxide is among the most popular intracanal medicaments due to its highly alkaline pH and antimicrobial properties. Evidence shows that long-term use of this medicament changes the organic matrix of dentin and subsequently modifies its mechanical properties and can weaken the dentin structure.[5,6] CH has adverse effects such as dissolution, denaturation, and hydrolysis of organic materials and degradation of bond between the hydroxyapatite crystals and collagen fibrils. In present study, no reduction was noted in bond strength of fiber post to dentin in CH group and the bond strength was higher than that of the control group. Andreasen et al showed cumulative negative effects of CH used as intracanal medicament for long durations of time up to 12 months. They discussed that short-term (30 days) use of CH had no adverse effect on root dentin as seen in this study.[6] On the other hand, a study assessed the short-term effects of CH on dentin strength and indicated that the mean compressive force in teeth filled with CH was significantly lower than that of the control group, and root dentin in teeth subjected to 30-day application of CH required less compressive force to break. Moreover, it has been discussed that use of CH as intracanal medicament decreases the dentin strength by 15% after 1 month of use and by 50% after 1 year of use. They explained that over time CH modifies the carboxylate and phosphate groups and causes collapse of dentin structure. This change causes degradation of proteins and proteoglycans and can degrade the bond of collagen network to hydroxyapatite crystals.[5] On the contrary, Carvalho et al reported that those effects were insignificant in short-term use of CH and showed an increase in the bond strength of sealer following the use of CH medicament for 14 days and assumed that CH increased permeability of dentin surface and caused better penetration of adhesive into dentin[34]., According to the results of this study and those of Carvalho et al,[34] it may be concluded that changes in dentin surface during this time period are not significant enough to negatively affect the bond strength of fiber post to resin. Also, it is assumed that short-term application of CH enables better penetration of cement into root dentin and consequently improves the bond strength of fiber post.

These results were also in agreement with those of Zare Jahromi et al, who showed that 1-week application of CH increased the bond strength of post to root dentin.[35]

To overcome some of the physicochemical limitation of CH, the combination of CH with other antibacterial substances has been proposed. Due to the broad-spectrum antimicrobial activity of CHX, it has been suggested as an alternative to CH or in combination with CH. It acts as an activity vehicle for CH and together with CH it has the ability to reduce the bacterial load.[36] In present study, CHX was used in gel form; therefore, it had a longer contact with dentin surface. CHX gel as an antimicrobial agent in combination with CH enhanced the bond strength of self-etch resin and subsequently fiber post to root dentin compared with the control group. Aside from its antimicrobial properties, CHX serves as a strong matrix metalloproteinase inhibitor. In other words, it inhibits endogenic collagenolytic activities in dentin. These collagenolytic activities cause degeneration of collagen fibrils and decrease the bond strength over time resulting in eventual failure of

resin-dentin bond.[37] Also, CHX bonds to surfaces (such as hydroxyapatite) covered with acidic proteins and is released over time in cationic form. This property is referred to as substantivity. In other words, due to inhibition of matrix metalloproteinases, substantivity and remaining in dentin matrix, CHX results in formation of a more stable hybrid layer after the application of resin cements.[17] These factors seem to enhance the bond strength. Alandia-Román showed that application of CHX as an irrigating solution resulted in higher bond strength of post to root dentin, which was in agreement with our results.[38] Santos et al assessed the effect of intracanal irrigating solutions on the bond strength of self-etch adhesives to root dentin. In their study, CHX gel increased the bond strength due to its effect on dentinal tubules in deep areas and enhanced the infiltration of adhesive into dentinal tubules.[39] This finding was in accordance with present results. However, the results of current study showed that addition of CHX to CH did not improve the pull-out bond strength of fiber post in comparison to CH alone in line with a previous study.[35]A possible justification could be the difficulty of CHX gel removal that may interfere with the penetration of adhesive materials into the dentinal tubules.

In this study, application of TAP also improved the bond strength compared with the control group. The TAP also inhibits matrix metalloproteinases and proteinase.[40] With a mechanism of action similar to that of CHX, TAP results in formation of a durable and stable hybrid layer and yields higher bond strength. On the other hand, it has been shown that minocycline has a chelating effect and increases the bond of cement to dentin and is responsible for the dentin collagen protection. This paste has an acidic pH as well (pH=2.9), which may condition the dentin surface and result in stronger bond of resin cement to dentin. However, this acidic pH may also weaken the dentin structure[28] but according to the results of current study, application of TAP had a positive effect on bond strength of fiber post to root dentin.

The result of this study revealed that the bond strength after the application of DAP was not significantly different from the bond strength in the control group. A possible justification might be the absence of minocycline as an active chelator in DAP.

According to the limitation of this study, the application of various intracanal medicaments was not associated with negative effect on bond strength of fiber post. However, scanning electron microscopy assessment of root sections following the application of intracanal medicaments must be done before casting judgment on the positive/negative effect of intracanal medicaments on root dentin.

Conclusion

None of the tested intracanal medicaments had any adverse effect on bond strength of fiber post to root dentin. Application of CH, CHX plus CH, and TAP for 4 weeks as intracanal medicament increased the pull-out bond strength of fiber post to dentin as compared to the control group.

Conflict of Interest
None declared.

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