Effects of Calcium Hypochlorite and Sodium Hypochlorite, as Root Canal Irrigants, on the Bond Strength of Glass Fiber Posts Cemented with Self-Adhesive Resin Cement

Maryam Khoroushi¹, Maryam Amirkhani Najafabadi², Atiyeh Feiz¹*

1. Dental Materials Research Center, Department of Operative Dentistry, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
2. Dental Students Research Center, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran

Article Info

Article type: Original Article

Article History:
Received: 16 January 2018
Accepted: 6 December 2018
Published: 29 June 2019

*Corresponding author:
Dental Materials Research Center, Department of Operative Dentistry, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran
E-mail: feiz@dnt.mui.ac.ir

Cite this article as: Khoroushi M, Amirkhani Najafabadi M, Feiz A. Effects of Calcium Hypochlorite and Sodium Hypochlorite, as Root Canal Irrigants, on the Bond Strength of Glass Fiber Posts Cemented with Self-Adhesive Resin Cement. Front Dent. 2019;16(3):214-223. doi: 10.18502/fid.v16i3.1593

INTRODUCTION

A common finding in daily dental treatments is a tooth with a minimal coronal structure in need of a dental post for retention inside the canal, for better distribution of functional forces, and for the support of future
prostheses [1-3]. Disadvantages of metal posts, such as root fracture, weak aesthetics, and corrosion, and advantages of fiber posts, such as having an elastic modulus similar to that of dentin [4], reducing the rate of vertical root fractures [3,5,6] as a result of equal distribution of forces on the walls of the root canal [7], bonding to resin core materials, suitable aesthetics [6], and the possibility of root retreatment because of their easy retrieval from the root canal, have increased the use of fiber posts [8].

The adhesion between the tooth structure and adhesive cements is the result of physical and chemical interactions at the dentin-cement interface [9]. Various chemical substances are used as irrigants for chemical-mechanical preparation of root canals, aiming at disinfection, dissolving of pulp tissues, and smear layer removal [9]. Sodium hypochlorite (NaOCl) is a commonly used irrigant in root canal treatment due to its wide-spectrum antibacterial effect and its potential to dissolve necrotic tissue remnants [10]. In addition to its strong antibacterial effect which depends on the concentration of the available chlorine [10,11], sodium hypochlorite has the ability to remove organic contents, especially collagen. Sodium hypochlorite breaks down into sodium chloride (NaCl) and oxygen; the oxygen-rich layer is a strong inhibitor of the bond of resin cements to dentin [12,13]. Oxygen bubbles on the surface of cement and dentin interfere with the penetration of resin cements into dentinal tubules [14]. Sodium hypochlorite is thought to cause the oxidation of a number of compounds in the dentin matrix, especially collagen [12,15]. Radicals derived from dentinal proteins compete with vinyl free radicals produced by light activation of resins, leaving the end of the chain incomplete and the polymerization unfinished [13], thus compromising the bond strength of the adhesive system [16]; this also reduces the dentinal calcium and phosphate content [17], weakens the mechanical properties of dentin, such as the elastic modulus, bending strength, and hardness [18], and reduces the micro-mechanical interactions between adhesive resins and the root canal dentin after irrigation with sodium hypochlorite [19].

The search for a new irrigant has led to experimental studies on the use of calcium hypochlorite (Ca(OCl)_2). Dutta and Saunders [20] have recently introduced calcium hypochlorite as a root canal irrigant. The effect of calcium hypochlorite, as a root canal irrigant, on the bond strength of fiber posts luted to radicular dentin with resin cements has not yet been investigated. Hence, the aim of the present study was to carry out a comparative investigation on the effects of calcium hypochlorite and sodium hypochlorite, as root canal irrigants, on the bond strength of posts cemented with a self-adhesive resin cement. The null hypothesis of this study was that 5.25% calcium hypochlorite irrigant could not have a significant effect on the push-out bond strength of fiber posts to dentin.

MATERIALS AND METHODS

In this in-vitro experimental study, 40 single-canal premolars, recently extracted for orthodontic or periodontal reasons, without any cracks, root caries or curved canals, were selected. The teeth had similar mesiodistal and buccolingual diameters [1]. Surface debris was removed using periodontal scalers and hand instruments. The teeth were kept in 0.2% thymol solution [21] at room temperature. The teeth were decoronated perpendicular to the cementoenamel junction (CEJ) using a diamond disc (Skillbond, Jota, UK) such that 14 mm of the coronoapical length remained. The specimens were randomly divided into five groups of eight samples each, and then, the canals were irrigated as follows: Group 1: 0.9% normal saline (control), Group 2: 2.5% sodium hypochlorite, Group 3: 5.25% sodium hypochlorite, Group 4: 2.5% calcium hypochlorite, and Group 5: 5% calcium hypochlorite.

The root canal was cleaned using the conventional step-back technique with a #35 K-file (Mani Inc., Tochigi-Ken, Japan) until reaching the working length, and then, the
Calcium/Sodium Hypochlorites and Glass Fiber Posts

In order to determine the effect of the irrigants, the post space was irrigated for 60 seconds with 5 ml of the irrigant corresponding to each group. Then, the teeth were irrigated with 5 ml of distilled water and were dried with absorbent paper points. Afterward, the posts (Micro.Medica s.r.l., Robbio, PV, Italy) were tested inside the canals to evaluate their fit, and they were cleaned with alcohol, dried, and cemented using BisCem self-adhesive cement (Bisco Inc., Schaumburg, IL, USA). The specifications of the materials used in the present study are listed in Table 1.

In order to cement the posts, the cement was placed inside the canal using special injection points that slowly moved backward while the canal was filled. The post was kept inside the canal for 30 seconds to ensure its complete seating. Next, light-curing (Optilux 501, Kerr Demetron, Orange, CA, USA) was performed for 40 seconds. After cementing and coating the coronal surfaces of the teeth with a liquid composite (Denfil Flow, Vericom Laboratories Ltd., Anyang, Korea), the teeth were incubated at 37°C with 100% humidity for 24 hours. Then, they underwent 1,000 thermocycles at 5-55°C with a dwell time of 30 seconds and a transfer time of 10 seconds. All the prepared roots were mounted in acrylic resin (Acropars, Marlic Medical Industries Co., Tehran, Iran), and three 1.1-mm-thick slices were obtained from the middle part of the root (n=24 in each group). The sections were cut perpendicular to the longitudinal axis of the root. No failure occurred during cutting, and all the pieces were selected for the push-out test.

A pin with a diameter of 1 mm was used to exert the force on the posts. The pin was placed on the specimens such that it was completely in contact with the post during the application.

Table 1: The specifications and the composition of the materials used in the present study

| Product                                    | Manufacturer                  | Composition                                               |
|---------------------------------------------|--------------------------------|-----------------------------------------------------------|
| BisCem self-adhesive resin cement           | Bisco Inc., Schaumburg, IL, USA| Bis (hydroxy-ethyl methacrylate)                          |
| (paste-paste dual syringe, automix)         |                                | Phosphate (base), tetra-ethylene glycol dimethacrylate, dental glass |
| Glass fiber post (90V, 011series)-conical type 2 | Micro.Medica s.r.l., Robbio, PV, Italy | Glass fiber post + epoxy resin                           |
| Calcium hypochlorite                        | Merck KGaA, Darmstadt, Germany | 100% calcium hypochlorite                                  |
| Sodium hypochlorite                         | Raga, Pakrood Co., Isfahan, Iran| 100% sodium hypochlorite                                  |
test. The direction of force application was from the apical aspect toward the coronal aspect so that the post could move toward the larger zone. Then, a push-out test was carried out for each section at a crosshead speed of 0.5 mm/minute using a universal testing machine (Walter & Bai, K21046, Löhningen, Switzerland). The maximum force at the point where the post was dislodged from the root section was considered as the bond failure point and was recorded in Newton (N). Then, the push-out bond strengths were calculated in Megapascal (MPa) by dividing the force at the bond failure point by the area of the bonded cross-section according to the following formula [1]:

\[ A = \pi (r + R) \sqrt{h^2 + (R - r)^2} \]

where “R” is the radius of the coronal third of the post, “r” represents the radius of the apical third of the post, and “h” shows the thickness of each specimen in millimeters (mm).

The failure type in each cross-section was evaluated using a stereomicroscope (MBC-10, SF-100, Lomo, St. Petersburg, Russia) at ×40 magnification. The failure patterns were classified as adhesive failure between cement and post, adhesive failure between cement and dentin, and mixed failure pattern.

**Scanning electron microscopy (SEM):**

One sample from each group was prepared for bonding interface analysis under an SEM (JSM-5410LV; JEOL, Tokyo, Japan) at ×2000 and ×5000 magnifications.

**Statistical analysis:**

The data were analyzed according to one-way analysis of variance (ANOVA) and Tukey's HSD (honestly significant difference) post-hoc test with the aid of SPSS 23 software (SPSS Inc., Chicago, IL, USA; α=0.05).

**Results**

Values related to the mean and standard deviation (SD) of the bond strengths (MPa) are reported in Table 2 for all experimental groups. The lowest bond strength belonged to the control group, while the highest bond strength belonged to the 5% calcium hypochlorite group. There was a statistically significant difference between the 5% calcium hypochlorite group and the other groups (P<0.001); however, the difference between the other groups was not significant. The results of the SEM analysis showed the penetration of the cement into dentinal tubules and the presence of resin tags in the control group (Fig. 1); the length of the resin tags reached 30 to 50 micrometers (μm). In the 2.5% sodium hypochlorite group (Fig. 2), the cement was separated from dentin, and no cement penetration was detected in dentinal tubules.

![Fig. 1. A scanning electron microscopic (SEM) image of a specimen in the normal saline group.](image-url)
Table 2: Mean and standard deviation (SD) of bond strength (MPa) in the tested groups

| Group Number | Group definition | Mean   | SD   | SE   | 95% Confidence Interval Lower Bound | Upper Bound | Min  | Max  |
|--------------|-----------------|--------|------|------|------------------------------------|-------------|------|------|
| 1            | NS(control)     | 7.28a  | 2.66 | 0.54 | 6.15                               | 8.41        | 4.64 | 15.9 |
| 2            | 2.5% SH         | 8.15a  | 2.51 | 0.51 | 7.09                               | 9.21        | 3.85 | 11.8 |
| 3            | 5.25% SH        | 8.38a  | 3.76 | 0.77 | 6.79                               | 9.97        | 3.27 | 20.5 |
| 4            | 2.5% CH         | 8.9a   | 3.13 | 0.64 | 7.58                               | 10.22       | 3.8  | 14   |
| 5            | 5% CH           | 11.84b | 2.04 | 0.42 | 10.98                              | 12.7        | 7.2  | 15.5 |
| Total        |                 | 9      | 3.22 | 0.29 | 8.32                               | 9.49        | 3.27 | 20.5 |

NS: Normal Saline, SH: Sodium Hypochlorite, CH: Calcium Hypochlorite, SD: Standard Deviation; SE: Standard Error; Min: Minimum; Max: Maximum; Data with different lowercase letters indicate significant differences (P<0.05, Tukey’s test)

Resin tags and the penetration of the cement into dentinal tubules can be seen in the SEM images of the 5.25% sodium hypochlorite group (Fig. 3); the length of the resin tags reached 30 to 60 μm. Resin tags and the penetration of the cement into dentinal tubules can also be seen in the SEM images of the 2.5% calcium hypochlorite group (Fig. 4); the length of the resin tags reached 40 to 90 μm.

Figure 5 shows resin tags and the penetration of the cement into dentinal tubules in the 5% calcium hypochlorite group; the length of the resin tags reached 60 to 100 μm. The failure pattern frequency in each group is reported in Table 3. In group 1, adhesive failure at the post-luting agent interface was reported as the most frequent type of failure. In group 2, no adhesive failure at the dentine-luting agent interface was reported.

Fig. 2. A scanning electron microscopic image of a specimen in the 2.5% sodium hypochlorite group.
Fig. 3. A scanning electron microscopic image of a specimen in the 5.25% sodium hypochlorite group.

Fig 4: A scanning electron microscopic image of a specimen in the 2.5% calcium hypochlorite group.

Fig. 5: A scanning electron microscopic image of a specimen in the 5% calcium hypochlorite group. 
c=cement, d=root canal dentin, r=resin tag)
### Table 3: Frequency (%) of different failure modes in the tested groups

| GN | Group  | AP | AD | M  |
|----|--------|----|----|----|
| 1  | NS     | 50 | 4.1| 45.9|
| 2  | 2.5% SH| 50 | 0  | 50 |
| 3  | 5.25% SH| 33.34| 8.32| 58.34|
| 4  | 2.5% CH| 41.67| 0  | 58.34|
| 5  | 5% CH  | 41.66| 0  | 58.34|

GN: Group Number; NS: Normal Saline; SH: Sodium Hypochlorite; CH: Calcium Hypochlorite; AP: Adhesive: post-luting agent interface; AD: Adhesive: dentin-luting agent interface; M: Mixed failure pattern

In groups 3, 4, and 5, mixed failure pattern was reported as the most frequent type of failure.

### DISCUSSION

In the present study, we carried out a comparative investigation on the effects of calcium hypochlorite and sodium hypochlorite, as root canal irrigants, on the bond strength of posts luted with a self-adhesive resin cement. When analyzing the obtained results, the null hypothesis of this study was rejected as the 5.25% calcium hypochlorite irrigant had a significant effect on the increase in the push-out bond strength.

Chemical solutions used for disinfection, cleaning, and completing the mechanical processes of instrumentation during root canal treatment cause physical and chemical changes, such as decreased microhardness and increased permeability of the root canal dentin [22,23]. The severity of the effects of these solutions is directly correlated with the concentration of their compounds and changes in the dentin layer [24]. Due to its antibacterial properties and tissue solving ability, sodium hypochlorite is used as a common irrigant in root treatment [25]. Use of this substance at 5% concentration reduces the dentinal calcium and phosphate content [17] and weakens the mechanical properties of dentin, such as the elastic modulus, bending strength, and hardness [18]. According to some studies, this solution reduces the bond strength of the post to radicular dentin [26,27], whereas some other studies have shown no decrease in bond strength after using this solution [28,29]. In the present study, no decrease was observed in bond strength after using sodium hypochlorite. This non-decrease in bond strength can be due to the final irrigation of root canal and post space with distilled water. In the present study, a self-adhesive cement was used to cement the post to radicular dentin. According to some researchers, self-adhesive resin cements do not have enough etching potential to remove the smear layer inside the root canal after preparation of the post space [29,30], while some other studies have reported better results about self-adhesive cements in this respect [3,31,32]. Nonetheless, it should be noted that these studies lacked a thermocycling/aging procedure and could not simulate the clinical conditions. The bonding mechanism of self-adhesive cements is based on micromechanical retention and chemical bonding. BisCem cement contains acidic phosphate monomers which establish chemical bonds to calcium hydroxyapatite [12,14]. In the present study, the bond strength in the control group was not significantly different than that in the 2.5% sodium hypochlorite, 5% sodium hypochlorite, and 2.5% calcium hypochlorite groups. Likewise, there was no significant difference between the 2.5% sodium hypochlorite and 5.25% sodium hypochlorite groups. It has been stated that the use of calcium hypochlorite solution on dentin increases the amount of calcium while decreasing the amount of carbon [33]. This finding suggests that the use of a calcium hypochlorite solution can result in changes in the chemical composition of the dentin surface by removing organic materials. In addition, the amount of calcium and phosphorus ions increases, which can be beneficial for mineralization process and formation of amorphous calcium phosphate phase in the hybrid layer; calcium and phosphorus ions are the mineral components of the primary dentin. New apatite crystals and calcium phosphate and calcium carbonate crystals may also form. These crystals may be attached...
to the surface through ionic bonds or may be surrounded by the adhesive [33]. According to the present study, the use of calcium hypochlorite, as a root canal irrigant, increases the bond strength of calcium groups. Because of the presence of calcium sediments in the environment and their probable entrance into the radicular dentin structure, and since the self-adhesive cement increases the bond strength through chemical bonding to these substances, BisCem self-adhesive cement resulted in the increased bond strength with chemical bonding to calcium hydroxyapatite, calcium phosphate crystals, and apatite crystals; however, this increase was not significant. This can be due to root canal irrigation after cleaning and shaping as well as post space irrigation with distilled water, which removes calcium sediments inside dentinal tubules resulting from the irrigant. Since this substance has been used at a low concentration, the volume of its sediments has been reduced by irrigation with distilled water; therefore, it was not able to significantly increase the bond strength. This difference may also become significant in case of an increase in the number of specimens and a change in the status and the concentration of the substance. Nonetheless, the 2.5% calcium hypochlorite group was significantly different than the 5% calcium hypochlorite group in this respect. In this study, the 5% calcium hypochlorite group showed the highest bond strength (11.84±2.04 MPa), which was significantly different than that of the rest of the groups. This may be due to the chemical bonding of BisCem cement to newly-formed apatite crystals or calcium phosphate crystals. Since the concentration of the calcium hypochlorite solution was appropriate and it was not removed by irrigation, the formation of apatite crystals or calcium phosphate crystals increased, resulting in a dramatic increase in bond strength. When analyzing the results of the present study, in the 2.5% sodium hypochlorite group, the highest failure rate belonged to the mixed failure pattern, which was consistent with a study conducted by Bitter et al [28]. No failure at the adhesive cement-dentin interface was reported in the 2.5% calcium hypochlorite and 5% calcium hypochlorite groups, and most of the failures were mixed failures, which is consistent with the higher bond strengths in these two groups compared to the other groups. The lower rate of failure at the adhesive cement-dentin interface can be due to the absence of thermomechanical loading, which has been shown to effectively change the percentage of the predominant failure pattern before and after loading [38]. In addition, in the present study, a jig was designed for the push-out test such that its bar was only in contact with the post surface, while the cement-dentin interface was supported by a stainless steel table that had a hole with a diameter similar to that of the post. This causes a more favorable failure pattern at the interface area while performing the test and prevents excess pressure on dentin. An SEM evaluation was also carried out in the present study. The SEM images were consistent with the results obtained in the groups. Resin tags were obviously more frequent in group 5, where the bond strength increased dramatically. It has been shown recently that the thickness of the hybrid layer and the morphology of resin tags have only a small effect on the bond strength [39]. The decrease in the intraradicular dentin bond strength is probably due to factors other than substrate morphology and can be due to clinical problems resulting from limited endodontic space and high C-factor [39]. The limitations of this in-vitro study included the small sample size and the inability to thoroughly simulate the clinical conditions.

**CONCLUSION**

Considering the limitations of the present study, it seems that the use of calcium hypochlorite solutions at an appropriate concentration increases the bond strength of fiber posts cemented with self-adhesive resin cements.
ACKNOWLEDGMENTS
The authors gratefully acknowledge that this report is based on a thesis (#395331) submitted to the School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran, in partial fulfillment of requirements for the DDS degree. This study was approved and financially supported by Isfahan University of Medical Sciences, Isfahan, Iran. This study was presented at IADR 2017, San Francisco, California, USA.

CONFLICT OF INTEREST STATEMENT
None declared.

REFERENCES
1. Marcos RM, Kinder GR, Alfredo E, Quaranta T, Correr GM, Cunha LF, et al. Influence of the resin cement thickness on the push-out bond strength of glass fiber posts. Braz Dent J. 2016 Sep-Oct;27(5):592-598.
2. Farina AP, Cecchin D, Garcia Lda F, Naves LZ, Pires-de-Souza Fde C. Bond strength of fibre glass and carbon fibre posts to the root canal walls using different resin cements. Aust Endod J. 2011 Aug;37(2):44-50.
3. Soares CJ, Pereira JC, Valdivia AD, Novais VR, Meneses MS. Influence of resin cement and post configuration on bond strength to root dentine. Int Endod J. 2012 Feb;45(2):136-45.
4. Erdemir U, Sar-Sancakli H, Yildiz E, Ozel S, Batur B. An in vitro comparison of different adhesive strategies on the micro push-out bond strength of a glass fiber post. Med Oral Patol Oral Cir Bucal. 2011 Jul 1;16(4):e626-34.
5. Goracci C, Ferrari M. Current perspectives on post systems: a literature review. Aust Dent J. 2011 Jun;56 Suppl 1:77-83.
6. Zicari F, De Munck J, Scotti R, Naert I, Van Meerbeek B. Factors affecting the cement-post interface. Dent Mater. 2012 Mar;28(3):287-97.
7. Torbörner A, Karlsson S, Ödman PA. Survival rate and failure characteristics for two post designs. J Prosthet Dent. 1995 May;73(5):439-44.
8. Grandini S. Endodontic Retreatment, in Ferrari M, Breschi L, Grandini S (editors). Fiber Posts and Endodontically Treated Teeth: A Compendium of Scientific and Clinical Perspectives. Wendywood, South Africa, Modern Dentistry Media cc, 2008:69.
9. Silva TMD, Fernandes VVB Junior, Santana RS, Marinho RMM, Valera MC, Bresciani E. Influence of Zingiber officinale Extract on Push-Out Bond Strength of Glass-Fiber Post. Braz Dent J. 2018 Jan-Feb;29(1):93-98.
10. Spanó JC, Barbin EL, Santos TC, Guimarães LF, Pécora JD. Solvent action of sodium hypochlorite on bovine pulp and physico-chemical properties of resulting liquid. Braz Dent J. 2001;12(3):154-7.
11. Zehnder M. Root canal irrigants. J Endod. 2006 May;32(5):389-98.
12. Nikaido T, Takano Y, Sasauchi Y, Burrow MF, Tagami J. Bond strengths to endodontically-treated teeth. Am J Dent. 1999 Aug;12(4):177-80.
13. Rueggeberg FA, Margeson DH. The effect of oxygen inhibition on an unfilled/filled composite system. J Dent Res. 1990 Oct;69(10):1652-8.
14. Ari H, Yaşar E, Belli S. Effects of NaOCl on bond strengths of resin cements to root canal dentin. J Endod. 2003 Apr;29(4):177-80.
15. Morris MD, Lee KW, Agee KA, Bouillaguet S, Pashley DH. Effects of sodium hypochlorite and RC-prep on bond strengths of resin cement to endodontic surfaces. J Endod. 2001 Dec;27(12):753-7.
16. Farina AP, Cecchin D, Barbizam JV, Carlini‐Júnior B. Influence of endodontic irrigants on bond strength of a self-etching adhesive. Aust Endod J. 2011 Apr;37(1):26-30.
17. Ari H, Erdemir A. Effects of endodontic irrigation solutions on mineral content of root canal dentin using ICP-AES technique. J Endod. 2005 Mar;31(3):187-9.
18. Sim TP, Knowles JC, Ng YL, Shelton J, Gulabivala K. Effect of sodium hypochlorite on mechanical properties of dentine and tooth surface strain. Int Endod J. 2001 Mar;34(2):120-32.
19. Santos JN, Carrilho MR, De Goes MF, Zaia AA, Gomes BP, Souza-Filho FJ, et al. Effect of chemical irrigants on the bond strength of a self-etching adhesive to pulp chamber dentin.
Dutta A, Saunders WP. Comparative evaluation of calcium hypochlorite and sodium hypochlorite on soft-tissue dissolution. J Endod. 2006 Nov;32(11):1088-90.

Amiri EM, Balouch F, Atri F. Effect of Self-Adhesive and Separate Etch Adhesive Dual Cure Resin Cements on the Bond Strength of Fiber Post to Dentin at Different Parts of the Root. J Dent (Tehran). 2017 May;14(3):153-158.

Babb BR, Loushine RJ, Bryan TE, Ames JM, Causey MS, Kim J, et al. Bonding of self-adhesive (self-etching) root canal sealers to radicular dentin. J Endod. 2009 Apr;35(4):578-82.

Morgental RD, Singh A, Sappal H, Kopper PM, Vier-Pelisser FV, Peters OA. Dentin inhibits the antibacterial effect of new and conventional endodontic irrigants. J Endod. 2013 Mar;39(3):406-10.

Slutzky-Goldberg I, Maree M, Liberman I, Heling I. Effect of sodium hypochlorite on dentin microhardness. J Endod. 2004 Dec;30(12):880-2.

Rosenfeld EF, James GA, Burch BS. Vital pulp tissue response to sodium hypochlorite. J Endod. 1978 May;4(5):140-6.

Manimaran VS, Srinivasulu S, Rajesh Ebenezar A, Mahalaxmi S, Srinivasan N. Application of a proanthocyanidin agent to improve the bond strength of root dentin treated with sodium hypochlorite. J Conserv Dent. 2011 Jul;14(3):306-8.

Rossi-Fedele G, Doğramacı Ej, Guastalli AR, Steier L, de Figueiredo JA. Antagonistic interactions between sodium hypochlorite, chlorhexidine, EDTA, and citric acid. J Endod. 2012 Apr;38(4):426-31.

Bitter K, Hambarayan A, Neumann K, Blunck U, Sterzenbach G. Various irrigation protocols for final rinse to improve bond strengths of fiber posts inside the root canal. Eur J Oral Sci. 2013 Aug;121(4):349-54.

Goracci C, Raffaelli O, Monticelli F, Balleri B, Bertelli E, Ferrari M. The adhesion between prefabricated FRC posts and composite resin cores: microtensile bond strength with and without post-silanization. Dent Mater. 2005 May;21(5):437-44.

Goracci C, Grandini S, Bossù M, Bertelli E, Ferrari M. Laboratory assessment of the retentive potential of adhesive posts: a review. J Dent. 2007 Nov;35(11):827-35.

Kahnamouei MA, Mohammadi N, Navimipour EJ, Shakerifar M. Push-out bond strength of quartz fibre posts to root canal dentin using total-etch and self-adhesive resin cements. Med Oral Patol Oral Cir Bucal. 2012 Mar 1;17(2):e337-44.

Cantaró A, Goracci C, Vichi A, Mazzoni A, Padda GM, Ferrari M. Retentive strength and sealing ability of new self-adhesive resin cements in fiber post luting. Dent Mater. 2011 Oct;27(10):e197-204.

Ferreira MB, Carlini Júnior B, Galafassi D, Gobbi DL. Calcium hypochlorite as a dentin deproteinization agent: Microleakage, scanning electron microscopy and elemental analysis. Microsc Res Tech. 2015 Aug;78(8):676-81.

Bitter K, Meyer-Lueckel H, Priehn K, Kanjunparambil JP, Neumann K, Kielbassa AM. Effects of luting agent and thermocycling on bond strengths to root canal dentine. Int Endod J. 2006 Oct;39(10):809-18.

Haapasalo M, Qian W, Portenier I, Waltimo T. Effects of dentin on the antimicrobial properties of endodontic medicaments. J Endod. 2007 Aug;33(8):917-25.

Khoroushi M, Mazaheri H, Tarighi P, Samimi P, Khalighinejad N. Effect of antioxidants on push-out bond strength of hydrogen peroxide treated glass fiber posts bonded with two types of resin cement. Restor Dent Endod. 2014 Nov;39(4):303-9.

Zicari F, Couthino E, De Munck J, Poitevin A, Scotti R, Naert I, et al. Bonding effectiveness and sealing ability of fiber-post bonding. Dent Mater. 2008 Jul;24(7):967-77.

Apak R, Güçlü K, Özyürek M, Bektaş Oğlu B, Bener M. Cupric ion reducing antioxidant capacity assay for food antioxidants: vitamins, polyphenolics, and flavonoids in food extracts. Methods Mol Biol. 2008;477:163-93.

Robbins JW. Restoration of Endodontically Treated Teeth, in Hilton TJ, Ferracane JL, Broome JC (editors). Summitt’s Fundamentals of Operative Dentistry: A Contemporary Approach. Hanover Park, IL, USA: Quintessence Publishing Co. Inc., 2013:572.