Effect of Post Space Cleaning Protocol on Bond Strength of Composite Fiber Post (In-Vitro Study)

Heba Badra*[1] and Faten Ghonimy[2]

Abstract:

Purpose: This study aimed to evaluate the effect of root canal cleaning protocol prior to cementation of Ribbon post and its influence on bond strength values between it and root dentin.

Material and methods: 24 freshly extracted human maxillary incisors were used in this study They were decapitated to make length in all teeth=13 mm, root canal treated and prepared to receive a post. Teeth were then divided into 4 equal groups (n = 6) according to the irrigating solution used: group (I): Ethylenediamine Tetraacetic Acid (EDTA), group (II): Sodium hypochlorite, group (III): chlorhexidine and group (IV): saline. Teeth were then mounted in acrylic blocks and sectioned horizontally perpendicular to their long axis to obtain a coronal, middle and apical section from each root. Specimens were then subjected to the push-out test using a universal testing machine at a cross-head speed of 1mm/min.

Results: It was revealed that EDTA solution had the highest bond strength of ribbond post to dentin wall.

Conclusions: EDTA was better than other solutions for cleaning of post space when using ribbon fiber posts. The coronal and middle of the root canal presented better bond strength values when compared to the apical section of the root canal.

Keywords: Push-Out; Ribbon; Cleaning protocol.

*[1] Assistant professor, Department of Endodontics, Ahram Canadian University, Cairo, Egypt.

[2] Assistant professor, Department of Endodontics, Ahram Canadian University, Cairo, Egypt.

Introduction:

The loss of tooth substance resulting from both endodontic therapy and pre-existing decay in endodontically treated teeth increased the probability of biomechanical failure. For these teeth, intra radicular posts are recommended to help to distribute intraoral stresses throughout the roots of the teeth and support the retention of artificial crowns. Many post systems have been proposed throughout the years, including the more contemporary translucent fibre posts (FP), pre-fabricated metallic posts, and the early cast metallic posts. Post and core can distribute or reinforce the tooth against intraoral stresses by equally dispersing torquing forces inside the radicular dentin to supporting tissues. While doing so, stresses can be distributed throughout the root and the core, which restored the missing coronal tooth structure and assisted in maintaining the restoration, will be retained. [1] .

It becomes important to utilize a post-and-core to provide retention and resistance form for the tooth-restoration unit when maintaining an endodontically treated tooth requires a full crown [2] . For the post-and-core material to better withstand the stresses of occlusal contact and avoid tooth fracture or post debonding, it should possess mechanical and physical qualities similar to those of dentin [3] .

The posts' adherence to the root dentin may be compromised if filling material remnants were removed but remained following post space preparation. To efficiently remove these residues, promote adequate luting, and guarantee optimal adhesion, it is imperative to investigate innovative cleaning techniques. The bonding agents and proper interface preparation combined to achieve the best adhesion [4]. The exposure of collagen and resin fibers to the dentinal tubules is exploited by the bonding technique. This cleaning and preparation of the canal surface is necessary to promote the formation of the hybrid layer and resin tags [5, 6, 7] .

A variety of dentin surface cleaning solutions, including sodium hypochlorite (NaOCl), ethanol, ethylene acetate, chlorhexidine gluconate, and ethylenediamine tetraacetic acid (EDTA), are advised in order to accomplish a more thorough cleaning of the canal. It is unclear from the literature what happens to them after post space preparation, despite the fact that their use and effectiveness during root canal preparation have been well proven [8,9] .

The introduction of non-metallic post systems received much attention in the past few years. Numerous tooth-colored posts

have been created, including fiber-reinforced posts, all-zirconium posts, and zirconia coated CFP [10].

For dental composites and acrylics, a bondable reinforcement ribbon made of leno-woven polyethylene, sometimes known as "Ribbond," provides protection against fracture failures. Its unique weave and use of high-strength fibers in construction provide it with unmatched fracture toughness and crack-stopping ability compared to other forms of reinforcement. A variety of clinical applications, including tooth splinting, tooth replacement, emergency dental care, strengthening of resin temporary fixed prosthodontic restorations, orthodontic retention have been effectively performed with ribbond [11] . The application of resin cement for post-to-canal preparation gained significant attention in the past year [12,13] . In certain laboratory, it has been discovered that resin cement considerably improves post retention [14,15,16] .

The current study evaluated the effect of root canal cleaning protocol prior to cementation of Ribbon post and its influence on bond strength values between it and root dentin.

Material and Methods:

1. **Ethical Approval**

The study had been approved by the Research Ethics Committee, faculty of Dentistry, Ahram Canadian University; Research number: IRB00012891#48.

2. **Sample size Calculations:**

Sample size was calculated depending on a previous study (Macário et al.) **[17]** as a reference, according to this study, the minimally accepted sample size was 6 per group, when the mean standard deviation is 3.82 ±1.9, the mean ± standard deviation of another group is 6.9 ±1.01, when the power was 80 % & type I error probability was 0.05. Independent t test was performed by using G Power 3.1.9.7.

3. **Selection of samples:**

24 single-rooted freshly extracted human central incisors with mature apices had been used in this study. Before use, each tooth had been placed in (5.25%) NaOCl for two hours for surface disinfection and periodontal ligament removal followed by storage in distilled water until use.

4. **Preparation of samples:**

Initial radiographs were taken to confirm root canal patency. All teeth were mechanically scaled by means of an ultrasonic scaler to remove any remaining bone, calculus, or soft tissue. Teeth were decapitated 2 mm coronal to the cementoenamel junction with average root length 13mm (± 1 mm) using low speed diamond stone.

5. **Root canal treatment of the teeth**

Root canal treatment was done using crown-down technique utilizing rotary pepsi files (FANTA PEPSI GOLD) according to the manufacturer's instructions up to #40 taper 4 instrument. The pepsi rotary files system was connected to an endodontic micro-motor (Wismy). Each canal was irrigated with 2 ml of 5.25% sodium hypochlorite (NaOCl) at each file size by means of a 27-gauge needle. Obturation was done using lateral condensation technique and resin sealer (ADSEAL, Meta Biomed Co., Korea).

Universal bonding agent (Single Bond Universal Adhesive, 3M, USA) had been applied and light cured for 20 second then a small amount of flowable composite (G-aenial Universal Flow, GC, USA) applied and light cured to establish coronal seal. After that, the teeth were placed in a clean glass container with 0.9% saline solution inside. The glass container was then placed in an incubator set at 37 °C for a week to guarantee that the resin sealer had fully set.

6. **Post space preparation**

Radicular preparation using gates glidden (size 1-2-3) (Mani, Italy) for removal of the gutta percha were used in sequential order to prepare the post space inside the root canals. All rotary instruments introduced inside the canal were mounted on a low-speed handpiece with internal coolant and were set to a standardized length of 10 mm to ensure at least 3 mm apical seal of gutta percha.

7. **Sample grouping**

Samples of this study (n=24) were classified into 4 groups according to irrigating solutions used into :

Group (I) Ethylenediamine Tetraacetic Acid (EDTA)

Root canals (n=6) were irrigated with 10 mL of EDTA for 60 seconds by means of a 27-gauge needle of plastic syringe

Group (II) Sodium Hypochlorite (NaOCl).

Root canals (n=6) were irrigated with 10 mm NaOCl for 60 seconds by means of a 27-gauge needle of plastic syringe

Group (III) Chlorhexidine Gluconate (CHX).

Root canals (n=6) were irrigated with 10 ml for 60 seconds by means of a 27-gauge needle of plastic syringe

Group (IV) Saline (Control):

Root canals (n=6) were irrigated with 10 ml saline for 60 seconds by means of a 27-gauge needle of plastic syringe

Finally, post spaces for all root canals were washed with 5 mL of distilled water and dried with absorbent paper tips

8. **Polyethylene Fibre Ribbon as Post Material (Figure 1) :**

Following the paper-point drying process, the root canal wall and the remaining tooth surface were etched for 15 seconds using 37% phosphoric acid (Meta Biomed Co., Korea), and then the area was thoroughly cleaned for 30 seconds. After dryness of post space, Universal bonding agent (Gluma) was applied and light cured for 30 seconds.

Ribbon was cut off at length (10 mm) by its special scissor. Ribbon post was placed after injecting the root canals by G-CEM resin cement (US English) using an endodontic plugger. Light curing of resin cement was done after placement of post for 40 seconds.

For the coronal reconstruction, the dentin had been conditioned for 15 seconds with 37 % phosphoric acid (Condac 37,FGM), washed with water, and dried with absorbent paper. The dentin adhesive (Ambar bond APS, FGM) had been applied and light-cured for 30 seconds. Direct composite resin (Opallis composite, FGM company) had been placed over the cervical margin of the root. Then, light activation (SDI Radii-Cal LED curing light) had been performed for 20 seconds per surface. Ultrafine diamond bur (3118F; KG Sorensen), abrasive paper discs (SofLex; 3M ESPE, St Paul, MN, USA) and silicone tips (Poligloss, Microdont, São Paulo, SP, Brazil) were used for finishing the final composite restoration.

9. **Bonding strength test**

Using a precision saw, the root canals were first placed in acrylic resin blocks and then cut horizontally perpendicular to their long axis. From every root, three post-dentine sections measuring two millimetres in thickness each were extracted: coronal (C), middle (M), and apical (A). A permanent marker was used to mark each item on its coronal surface.

After ensuring that the post was centered in the jig's hole and that the coronal surface faced the jig, each specimen was fastened in a specially designed loading device (push-out jig). The push-out test was carried out by using a cylindrical punch (plunger) with a 1.2 mm diameter that was fixed on a universal testing machine to apply a compressive load to the apical aspect of each slice. (Figure 2)

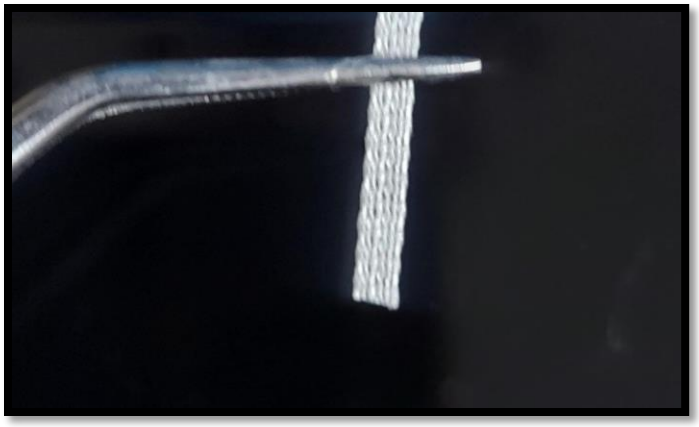

Figure 1: Polyethylene Fiber Ribbond

Figure 2: Universal Test Machine

Results:

Comparison between different sections:

Comparison between different sections was performed by using One Way ANOVA test which revealed insignificant difference in bond strength between them in group I (P=0.23), while there was significant difference between them in group II (P=0.003), group III (P<0.001) and group IV (P=0.002). Then Tukey's Post Hoc test for multiple comparisons was performed and revealed that Coronal and middle sections were significantly the highest bond strength

with insignificant difference between them Table (1), Figure (3).

Comparison between different groups:

Comparison between different groups was performed by using One Way ANOVA test which revealed insignificant difference between them in coronal section (P=0.051), while revealed significant difference between them in apical section (0.03). Then Tukey's Post Hoc test for multiple comparisons was performed and revealed that group I was significantly the highest in bond strength in apical section, while there was insignificant difference between other groups. Group I had the highest bond strength between all groups Table (1), Figure (3).

Table (1) : Mean and standard deviation of coronal, middle and apical sections in all group and comparison between them:

	Coronal		Middle		Apical		P value
	M	SD	M	SD	M	SD	
Group I (EDTA)	17.18 ^{aA}	2.4	15.59 ^{aA}	3.15	11.70 ^{aA}	6.49	0.23 ns
Group II (NaOCL)	12.88 ^{aA}	3.12	12.37 ^{aA}	4.19	4.80 ^{bB}	1.19	0.003*
Group III (CHX)	13.72 ^{aA}	3.13	12.47 ^{aA}	1.5	7.69 ^{bB}	3.48	<0.0001*
Group IV (Control)	13.72 ^{aA}	1.95	11.32 ^{abA}	2.1	7.33 ^{bB}	1.34	0.002*
P value	0.051 ns		0.09 ns		0.03*		

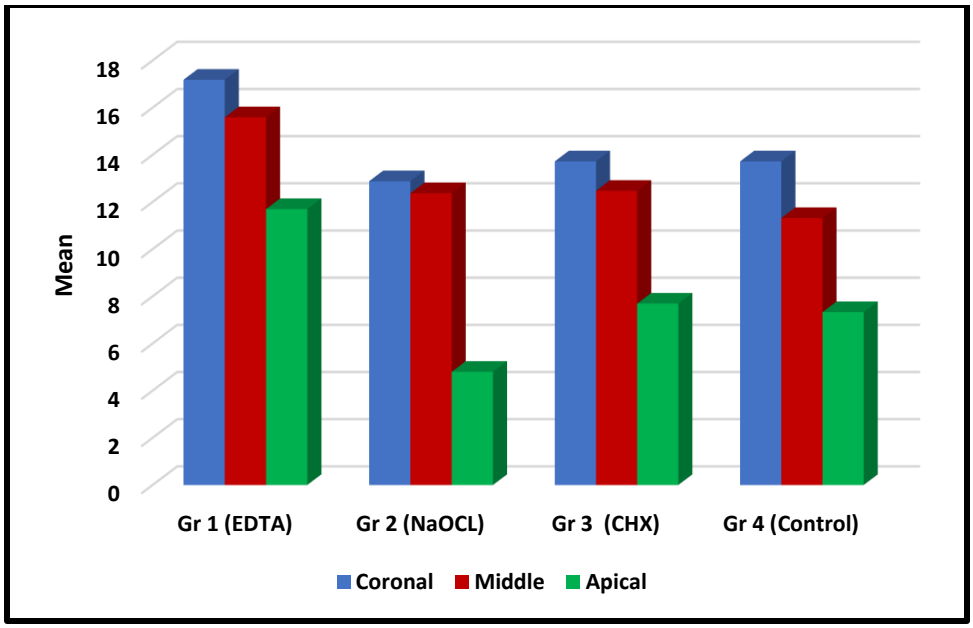

Figure (3): Bar chart representing coronal, middle and apical sections in all group.

Discussion:

The majority of damage to teeth undergoing endodontic treatment results from trauma, decay, prior restorations, and access cavity preparation. Consequently, these teeth's resistance and retention form are compromised, which leads to a breakdown in their ability to function. For teeth that have had endodontic treatment, using posts is therefore often advised [18] .

For standardization, the same operator performed the root canal treatment. Additionally, all materials utilized and examined in this investigation according to the manufacturer's instructions [19]. The reason for using ADSEAL resin sealer was because eugenol-containing sealers could change how resin cement polymerizes and interfere with the adhesive qualities of resin-based cement [20].

Heat generation had been reduced during drilling and prevent denaturing of the dentine collagen, which could affect the bond strength, a low-speed handpiece with internal coolant mounted on an electric micro-motor with built-in coolant was used to remove gutta percha and drill in sequential order (1-2-3) during the preparation of the post space [21, 22] .

In several clinical applications, such as orthodontic retention and the reinforcement of resin provisional fixed prosthodontic restorations, a leno-woven polyethylene ribbon known as Ribbond Bondable Reinforcement Ribbon has shown effective [23] In addition, it was used to splint teeth, manage dental emergencies, and replace missing teeth. The use of resin cement to connect a post into a prepared canal has garnered a lot of attention in the past year [12,13] . Resin cement has been demonstrated

in several laboratory studies to significantly improve post retention [14, 16] .

In endodontically treated teeth, post space preparation involves removing gutta-percha and sealers, which cause debris and smear layer to accumulate on root canal walls and potentially obstruct dentinal tubules [24] Since the smear layer promotes dentine permeability, it appears to be preferable to eliminate it [25]. The demineralized radicular dentine surface and the development of resin tags provide micromechanical retention that makes fibre posts and resin luting systems sufficiently hard to root canal walls [5]. As a result, the weak adhesion of the smear layer to dentine occurs when adhesive systems are used without removal of the smear layer, which reduces the bonding of adhesive to canal walls [16].

The organic and inorganic components of the smear layer have not yet been dissolved by any irrigation solution. The primary goal of irrigation is to get rid of the trash and smear layer [16] . Various irrigants, such as 5.25% NaOCl and 17% EDTA, have been shown to be effective. Moreover, 2% CHX is also indicated for root canal therapy because of its biocompatibility and antibacterial action [25] .

The bivalent cationic substance EDTA is used to preferentially chelate calcium ions while eliminating hydroxyapatite and non-collagenous proteins from the smear layer during restorative procedures [26] . Its low decalcification ability and minimal impact on the dentin allow the adhesive system's functional monomer to provide a stronger chemical connection. Due to the existence of more residual apatite crystals in the collagen matrix, this solution also produces a thinner hybrid layer without collagen denaturation, allowing the resinous agent to greater penetration in the collagen matrix [27] . According to Gu et al. **[28]** EDTA irrigation for 5 minutes resulted in severe root dentin erosion, although irrigation for less than 1 minute dramatically reduced smear layer loss. The EDTA-irrigated group in the current investigation displayed the highest bond strength among the four groups and revealed no discernible difference in bond strength between the three root segment samples within the same group.

NaOCl reduces resin's ability to adhere to interradicular dentin. When NaOCl breaks down, oxygen and sodium chloride are released into the canal, which can pass into the dentinal tubules and prevent adhesive systems from totally polymerizing. Additionally, the collagen-degrading effects of sodium hypochlorite could weaken the bonds between root dentin and bone **[28]** . Therefore, in present study, it had the lowest bond strength between the groups and had significant difference in between three segments of root samples in the same group.

According to the current investigation, the bond strength values of 2% chlorhexidine gluconate were comparable to those of the other groups. It was previously reported that there were no significant differences in the bond strength measurements when compared to distilled water [29] . This is in agreement with other studies that shown CHX had no detrimental effects on the immediate or long-term bond strength in post-bond cementation [30, 31] .

The saline solution group has no effect on the bonding strength in the current study. It has neither chelating nor antibacterial properties, and it cannot degrade organic tissue. It is therefore commonly used in combination with other root canal preparation methods.

However, saline solution outperformed EDTA in terms of bond strength values, as reported by Barreto et al [32] .

In all study groups, there was no significant difference in average push-out bond strength between coronal and middle levels. However, compared to other parts, the coronal level has demonstrated greater push-out bond strength. Studies showed that the tubule density is larger in the coronal and middle thirds of the root canal than in the apical region, and that the tubule diameter decreases in the apical direction. The strongest adhesion was likely achieved in the coronal sections, based on the variation in tubule count [33, 34, 35] .

Conclusions:

-The bond strength between ribbon fiber post and dentin differed according to the irrigating solution used prior to cementation.

-EDTA was better than other solutions for cleaning of post space when using ribbon fiber posts. The coronal and middle sections of the root canal presented better bond strength values when compared to the apical section of the root canal.

References:

(1) Rocca GT, Daher R, Saratti CM, Sedlacek R, Suchy T, Feilzer AJ, Krejci I. Restoration of severely damaged endodontically treated premolars: The influence of the endo-core length on marginal integrity and fatigue resistance of lithium disilicate CAD-CAM ceramic endo crowns. Journal of dentistry. 2018 Jan 1;68:41-50.

(2) Gonzaga CC, Correr GM. CAD/CAM post-and-core using different esthetic materials: fracture resistance and bond strengths. Am J Dent. 2017 Dec;30(6):299-304.

(3) Torabi K, Fattahi F. Fracture resistance of endodontically treated teeth restored by different FRC posts: An in vitro study. Indian Journal of Dental Research. 2009 Jul 1;20(3):282.

(4) Lo Giudice G, Cutroneo G, Centofanti A, Artemisia A, Bramanti E, Militi A, Rizzo G, Favaloro A, Irrera A, Lo Giudice R, Cicciù M. Dentin morphology of root canal surface: A quantitative evaluation based on a scanning electronic microscopy study. BioMed Research International. 2015 Aug 27;2015.

(5) Gu XH, Mao CY, Kern M. Effect of different irrigation on smear layer removal after post space preparation. Journal of endodontics. 2009 Apr 1;35(4):583-6.

(6) Serafino C, Gallina G, Cumbo E, Ferrari M. Surface debris of canal walls after post space preparation in endodontically treated teeth: a scanning electron microscopic study. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2004 Mar 1;97(3):381-7.

(7) Giudice GL, Cicciù M, Cervino G, Lizio A, Visco AM. Flowable resin and marginal gap on tooth third medial cavity involving enamel and radicular cementum: A SEM evaluation of two restoration techniques. Indian Journal of Dental Research. 2012 Nov 1;23(6):763.

(8) Lo Giudice G, Lizio A, Giudice RL, Centofanti A, Rizzo G, Runci M, Alibrandi A, Cicciù M. The effect of different cleaning protocols on post space: A SEM study. International Journal of Dentistry. 2016 Sep 28;2016.

(9) Goldman M, DeVitre R, White R, Nathanson D. Clinical Science An SEM Study of Posts Cemented with an Unfilled

Resin. Journal of Dental Research. 1984 Jul;63(7):1003-5.

(10) Sirimai S, Riis DN, Morgano SM. An in vitro study of the fracture resistance and the incidence of vertical root fracture of pulpless teeth restored with six post-and-core systems. The Journal of prosthetic dentistry. 1999 Mar 1;81(3):262-9.

(11) Rudo DN, Karbhari VM. Physical behaviors of fiber reinforcement as applied to tooth stabilization. Dental Clinics of North America. 1999 Jan 1;43(1):7-35.

(12) Fernandes AS, Dessai GS. Factors affecting the fracture resistance of post-core reconstructed teeth: a review. International Journal of Prosthodontics. 2001 Jul 1;14(4).

(13) Robbins JW. Restoration of the endodontically treated tooth. Dental Clinics. 2002 Apr 1;46(2):367-84.

(14) Ferrari M, Vichi A, Grandini S, Goracci C. Efficacy of a Self-Curing Adhesive--Resin Cement System on Luting Glass-Fiber Posts into Root Canals: An SEM Investigation. International Journal of Prosthodontics. 2001 Nov 1;14(6).

(15) Mendoza DB, Eakle WS, Kahl EA, Ho R. Root reinforcement with a resin-bonded preformed post. The Journal of prosthetic dentistry. 1997 Jul 1;78(1):10-4.

(16) Wong B, Utter JD, Miller BH, Ford JP, Guo IY. Retention of prefabricated posts using 3 different cementing procedures. injournal of dental research 1995 jan 1 (vol. 74, pp. 181-181). 1619 duke st, alexandria, va 22314: amer assoc dental research.

(17) Macário TR, Carvalho RF, Domingues PB, Maia BD, Marinho CC, Barcellos AS, Junqueira RB. Evaluación del Protocolo de Limpieza del Conducto Radicular sobre la Resistencia de la Unión de Postes de Fibra de Vidrio. International journal of odontostomatology. 2021 Jun;15(2):427-33.

(18) Uthappa R, Mod D, Kharod P, Pavitra S, Ganiger K, Kharod H. Comparative evaluation of the metal post and fiber post in the restoration of the endodontically treated teeth. Journal of Dental Research & Review. 2015 Apr 1;2(2).

(19) Elkhodary S, Elbasty R. The effect of different irrigation materials and application techniques on push-out bond strength of fiber post to root dentin. Egyptian Dental Journal. 2018 Oct 1;64(4-October (Fixed Prosthodontics, Dental Materials, Conservative Dentistry & Endodontics)):3895-906.

(20) Mosharraf R, Zare S. Effect of the type of endodontic sealer on the bond strength between fiber post and root wall dentin. Journal of Dentistry (Tehran, Iran). 2014 Jul;11(4):455

(21) Armstrong SR, Jessop JL, Winn E, Tay FR, Pashley DH. Denaturation temperatures of dentin matrices. I. Effect of demineralization and dehydration. Journal of endodontics. 2006 Jul 1;32(7):638-41.

(22) Ra'fat IF. Effect of cooling water temperature on the temperature changes in pulp chamber and at handpiece head during high-speed tooth preparation. Restorative dentistry & endodontics. 2019 Feb 1;44(1).

(23) Rudo DN, Karbhari VM. Physical behaviors of fiber reinforcement as applied to tooth stabilization. Dental Clinics of North America. 1999 Jan 1;43(1):7-35.

(24) Srirekha A, Rashmi K, Hegde J, Lekha S, Rupali K, Reshmi G. An in vitro evaluation of passive ultrasonic agitation of different

irrigants on smear layer removal after post space preparation: a scanning electron microscopic study. The Journal of Indian Prosthodontic Society. 2013 Sep;13:240-6.

(25) Hülsmann M, Heckendorff M, Schäfers F. Comparative in-vitro evaluation of three chelator pastes. International Endodontic Journal. 2002 Aug 1;35(8):668-79.

(26) Martinho FC, Carvalho CA, Oliveira LD, de Lacerda AJ, Xavier AC, Augusto MG, Zanatta RF, Pucci CR. Comparison of different dentin pretreatment protocols on the bond strength of glass fiber post using self-etching adhesive. Journal of endodontics. 2015 Jan 1;41(1):83-7.

(27) Carvalho RM, Tay F, Sano H, Yoshiyama M, Pashley DH. Long-term mechanical properties of EDTA-demineralized dentin matrix. Journal of Adhesive Dentistry. 2000 Sep 1;2(3).

(28) Alaghemand H, Mirzae M, Ahmadi E, Saidi A. Effect of different post-space pretreatments on fiber post bonding to root dentine. Dental Research Journal. 2013 Jul;10(4):545.

(29) Jiang LM, Lak B, Eijsvogels LM, Wesselink P, van der Sluis LW. Comparison of the cleaning efficacy of different final irrigation techniques. Journal of endodontics. 2012 Jun 1;38(6):838-41.

(30) Bitter K, Eirich W, Neumann K, Weiger R, Krastl G. Effect of cleaning method, luting agent and preparation procedure on the retention of fibre posts. International endodontic journal. 2012 Dec;45(12):1116-26.

(31) Cecchin D, de Almeida JF, Gomes BP, Zaia AA, Ferraz CC. Influence of chlorhexidine and ethanol on the bond strength and durability of the adhesion of the fiber posts to root dentin using a total etching adhesive system. Journal of endodontics. 2011 Sep 1;37(9):1310-5.

(32) Lindblad RM, Lassila LV, Salo V, Vallittu PK, Tjäderhane L. Effect of chlorhexidine on initial adhesion of fiber-reinforced post to root canal. Journal of dentistry. 2010 Oct 1;38(10):796-801.

(33) Barreto MS, Rosa RA, Seballos VG, Machado E, Valandro LF, Kaizer OB, Só MV, Bier CA. Effect of intracanal irrigants on bond strength of fiber posts cemented with a self-adhesive resin cement. Operative Dentistry. 2016;41(6):e159-67.

(34) Zicari F, Couthino E, De Munck J, Poitevin A, Scotti R, Naert I, Van Meerbeek B. Bonding effectiveness and sealing ability of fiber-post bonding. Dental Materials. 2008 Jul 1;24(7):967-77.

(35) Rathke A, Haj-Omer D, Muche R, Haller B. Effectiveness of bonding fiber posts to root canals and composite core build-ups. European journal of oral sciences. 2009 Oct;117(5):604-10.