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THE EFFECT OF DIFFERENT IRRIGATION MATERIALS AND APPLICATION TECHNIQUES ON PUSH-OUT BOND STRENGTH OF FIBER POST TO ROOT DENTIN

Sherif Elkhodary * *and* Reham Elbasty**

ABSTRACT

Statement of the problem: Achieving a reliable bond to root canal dentin is a subject of ongoing research. Improving the bond strength between root dentin and fiber posts through different irrigation materials and techniques used during post space preparation has been suggested; yet, there is a few data regarding the irrigation materials and application techniques that could be used to achieve an optimum bond.

Purpose: The aim of this invitro study was to evaluate the effect of different irrigation materials (NaOCl + EDTA and Qmix) and application techniques (syringe, passive ultrasonic irrigation, XP finisher) on the push-out bond strength of fiber posts to root dentin.

Materials and methods: Forty eight human premolars, with straight root canals and average root length of 17±1 mm were selected. The clinical crowns were cut 2mm above the cementoenamel junction. Root canal treatment was done with ProTaper universal rotary instruments to size F4 and then obturated with lateral condensation technique and AdSeal sealer. Teeth were then stored in distilled water for 7 days at 37°C after sealing of the access cavity with temporary filling free from eugenol. For each tooth, post space preparation was done using gates glidden drills leaving 4-5 mm of gutta percha as apical seal. FibreKleer post tapered drill corresponding to the glass fiber post size was used to remove any residual root filling. The prepared roots were equally and randomly divided into two main groups (n = 18) before post cementation as follows; **Group I:** Irrigation with 10 ml of 2.6% NaOCL over 60 seconds followed by 5 ml EDTA for another 60 seconds, **Group II:** Irrigation with 3 ml Q-mix for 60 seconds. Each of the two main groups was further divided into 3 subgroups, **Subgroup A (n = 6):** Conventional syringe irrigation (IA, IIA), **Subgroup B (n = 6):** Passive ultrasonic irrigation (PUI) was performed for 60 seconds (IB, IIB), **Subgroup C (n = 6):** XP finisher was used with a torque-controlled motor according to the manufacturer's instructions. The canal was filled with irrigant and the finisher was operated for 60 seconds using slow and gentle in-and-out movements (IC, IIC). All posts were tried-in, cleaned with alcohol, and then silanized with ceramic primer for 60 seconds then air dried. Cementation was done using Rely X Unicem 2 self adhesive resin cement.

* Lecturer of Endodontics, Faculty of Dentistry, Cairo University.
** Lecturer of Fixed Prosthodontics, Faculty of Dentistry Cairo University.

After the luting procedure, the coronal part of the posts was covered completely with resin-modified glass ionomer cement and the roots were stored in distilled water for 7 days at 37°C. Roots were embedded in epoxy resin and transversely sectioned perpendicular to the long axis of the root with an Isomet machine. It was pre-set to serially obtain six specimens (2 mm ± 0.1) thick, where two specimens corresponded to each root third. For push-out testing, each specimen was mounted in a custom made loading fixture then subjected to compressive loading with the apical surface upwards at a crosshead speed of 1 mm/min via a computer controlled testing machine. The maximum failure load was recorded in Newton and converted into MPa. Two teeth as a representative of each subgroup were split longitudinally after post space preparation and irrigation, and smear layer was examined using scanning electron microscope at 1, 4.5, and 8mm levels from the apical to the coronal third of the post space at 1000 magnification. Data were recorded, tabulated and statistically analysed.

Results: Regarding the push-out bond strength results; it was found that regardless of application techniques or radicular regions, there was no significant difference in the push-out bond strength between both irrigation solutions as proven by three-way ANOVA test, where (***NaOCl + EDTA ≥ Q mix)***. Irrespective to irrigation solutions or radicular regions, there was significant difference in the push-out bond strength between application techniques as demonstrated by three-way ANOVA test , where (***PUI ≥ XP > Syringe).*** Pair-wise Turkey's post-hoc showed no significant difference in the push-out bond strength between (***PUI*** and ***XP)***. Regardless of irrigation solutions or application techniques; there was no significant difference in the push-out bond strength between radicular regions as verified by three-way ANOVA test where (***cervical ≥ apical ≥ middle)***. Regarding the smear layer marking; it was found that there was non-significant difference between both irrigation solutions as proven by Chi square test where (***NaOCL+EDTA ≥ Qmix)***. There was also non-significant difference between irrigation application techniques as demonstrated by Chi square test where (***Syringe ≥ PUI≥ XP)***. In addition, there was non-significant difference between radicular regions as verified by Chi square test where (***apical ≥ middle ≥ cervical)***.

Conclusions Within the limitations of this study it was concluded that:

1. Q mix irrigation solution decreased the bond strength between root dentin and fiber posts when self adhesive luting agent was used.
2. The use of XP finisher and passive ultrasonic irrigation as irrigant activation devices improved the bond strength between root dentin and fiber posts compared to conventional syringe irrigation.

INTRODUCTION

Intraradicular posts, are often necessary for the restoration of root canal treated teeth because of extensive carious lesions, endodontic access cavity preparation, previous restorations and fractures[1]. The most common failures of radicular posts, include debonding, root fracture and endodontic lesions[2]. Fiber posts usually fail because of debonding[3,4]. When fiber posts are luted with a resin cement, two interfaces are formed, the dentin-resin cement and the resin cement fiber post. The weak point is the dentin-resin cement at either side of the interfaces[5,6]. This interface could be affected by factors, such as dentin conditions, orientation of dentinal tubules, irrigation solutions and techniques, depth of the intraradicular area, type of adhesive system and endodontic sealer[7,8].

The drilling during post space preparation creates a smear layer. This smear layer consists of gutta percha remnants and root canal sealer,[9] which covers the root canal dentin surface and directly affects the bond strength of the dentin-resin cement interface[10]. Post space irrigation may affect the strength of the cement bond with the root canal dentin. Although some researchers recommend sodium hypochlorite (NaOCl) for post space preparation irrigation, this procedure may adversely affect the resin cement bond strength [11]. The application of NaOCl and ethylenediaminetetraacetic acid (EDTA), may remove the smear layer, increase the penetration of the adhesive and accordingly, increase the resin bond strength[12]. Chlorhexidine (CHX) also has been used as an irrigant after post space preparation due to its antibacterial activity, substantivity, biocompatibility and the inhibition of the matrix metalloproteinase which is a collagen degrading enzyme[13]. Additionally, studies have shown that, CHX did not negatively affect the fiber post bond strength[14]. Recently, QMix (Dentsply Tulsa Dental, Tulsa, OK, USA), a novel irrigant for smear layer removal with added antimicrobial agents, has been developed. It consists of EDTA, CHX and a detergent. QMix, is a clear solution ready to use with no chairside mixing[15] which will be used to determine its effect on bond strength of glass fiber posts to root dentine.

Many techniques, have been used to remove the smear layer from root canal walls. A conventional syringe combined with sodium hypochlorite (NaOCl) irrigation has been commonly employed for the removal of the smear layer, however, it was found to be insufficient for cleaning root canals [16]. Recently, different irrigant activation devices have been introduced to increase irrigant flow, and its distribution within the root canal system[17]. Passive ultrasonic irrigation (PUI) (Acteon Group, Merignac, France) employs a stainless steel file for irrigant activation in the canal. It was concluded that ultrasonic activated irrigation was superior to conventional syringe irrigation [16]. XP-Endo finisher (XP) (FKG Dentaire, La Chauxde-Fonds, Switzerland) is a file based on the shape memory principles of NiTi alloy, with a small core, size #25 and no taper; it was designed to be used following any root canal preparation of size 25 or more to clean the highly complex morphologies, and difficult areas to be reached, as well as removing the smear layer[18].

The purpose of this in vitro study, was to evaluate the effect of different irrigation materials (Naocl + EDTA and Qmix) and application techniques (syringe, passive ultrasonic irrigation , XP finisher) on the push-out bond strength of fiber posts to root dentin

The null hypothesis was that there would be no difference in the push-out bond strength between fiber posts and root dentin when using different irrigation materials and application techniques and that the different root regions would exhibit similar push-out bond strength values.

MATERIALS AND METHODS:

In this experimental study, 48 sound human premolars with straight root canals and average root length of 17±1 mm were selected. The selected teeth were caries free and without fracture, cracks or previous restoration. After, the storage of teeth in 0.1% chloramine T for one week, they were stored in distilled water at 4˚C, and were used within three months after their extraction. The clinical crowns were cut 2mm above the cementoenamel junction with a diamond disc under copious cooling water.

Root canal treatment

Root canals were endodontically prepared at a working length of 1 mm from the apex. All root canals were prepared by the same operator. Canals were prepared using a crown-down preparation technique with ProTaper rotatory instruments (Dentsply-Maillefer, Ballaigues, Switzerland) to size F4. Irrigation was done using 5.25 % sodium hypochlorite between files and 17 % EDTA solution for 1 min as a final rinse. Root canals were rinsed with distilled water for 1 min and then dried with paper points. Afterwards, they were obturated with gutta-percha cones (META BIOMED CO.LTD, Korea) and AdSeal sealer (META BIOMED CO.LTD, Korea) with the lateral condensation technique. Once the endodontic treatment was completed, teeth were stored in distilled water for 7 days at 37 ˚C after sealing of the access cavity with temporary filling free from eugenol.

Post space preparation

The proper size of FibreKleer tapered glass fiber posts (Pentron Clinical, CA, USA) was selected with 1.4 mm diameter. For each tooth, post space preparation began with the removal of gutta percha to a depth of 12 mm using gates glidden drills (Dentsply-Maillefer) leaving a minimum apical seal of 4-5 mm. FibreKleer post tapered drill corresponding to the glass fiber post size was used to remove any residual root filling and complete canal preparation with water spray coolant and at a low speed.

The prepared roots were equally and randomly divided into two main groups (n = 18) according to the irrigation solution used before post cementation as follows;

Group I: Irrigation with 10 ml of 2.6% NaOCL over 60 seconds followed by 5 ml EDTA for another 60 seconds.

Group II: Irrigation with 3 ml Q-mix for 60 seconds.

Each of the two main groups was further divided into 3 subgroups according to the irrigation application techniques as follows;

Subgroup A (n = 6): Conventional syringe irrigation (IA, IIA)

Subgroup B (n = 6): Passive ultrasonic irrigation (PUI) was performed using a Satalec P5 Newtron ultrasonic system and an IrriSafe tip (size 25.00) taper file (Acteon Group) on the sixth power setting. The IrriSafe tip was inserted into the canal and the irrigant was ultrasonically activated for 60 seconds (IB, IIB).

Subgroup C (n = 6): XP finisher was used with a torque-controlled motor (X-Smart, Dentsply Maillefer) operated at 800 rpm and the torque was set to 1 Ncm, according to the manufacturer’s instructions. The canal was filled with irrigant and the finisher was operated for 60 seconds using slow and gentle in-and-out movements (IC, IIC).

The post spaces were dried using paper points in all groups before post cementation.

Post cementation

All posts were tried-in, cleaned with alcohol, and then silanized with Rely X ceramic primer (3M ESPE Dental products, St. Paul,USA) for 60 seconds then air dried. Cementation was done using Rely X Unicem 2 self adhesive resin cement (3M ESPE Dental products) as follows; first, attach the Endo Tip to the mixing tip of the Rely X capsule for application in the root canal and insert the Endo Tip as deeply as possible then apply the cement. Place the post in the root canal filled with the cement and apply moderate pressure to hold it in position. Remove the excess and light cure for 40 seconds.

After the luting procedure, the coronal part of the posts was covered completely with the resin-modified glass ionomer cement (Vitrebond Plus, 3M ESPE), and the roots were stored in distilled water for 7 days at 37 ˚C.

Push-out test procedure

Roots were embedded in epoxy resin and transversely sectioned perpendicular to the long axis of the root with a high precision digitally programmed machine (Isomet 5000, Buehler, Lake Buff, IL, USA) .It was pre-set to serially obtain six specimens 2 mm ± 0.1 thick by means of a water-cooled diamond saw, where two specimens corresponded to each root third: apical, middle and cervical. The exact specimens' thickness was measured using a digital caliper (Pachymeter, Electronic Digital Instruments, China). (Fig. 1)

Fig. (1) Specimens corresponding to each root third

Each specimen was marked on its coronal side with an indelible marker and then coded and photographed from apical and coronal surfaces using a stereomicroscope (SZ-PT; Olympus, Tokyo, Japan) at an original magnification of 65x. Calibration was performed by comparing an object of known length, a ruler in this study, using the ''Set Scale'' tool generated by the image analysis software (Image J; NIH, Bethesda, MD). The diameter of the post was then measured and the radius was calculated.

Each specimen was mounted in a custom made loading fixture (metallic block with circular cavity at the middle, this cavity for specimen housing has a central hole to facilitate displacement of extruded post) then subjected to compressive loading with the apical surface upwards at a crosshead speed of 1 mm/min via a computer controlled testing machine (Model 3345; Instron Industrial Products, Norwood, MA, USA).

Load was applied by a plunger of (1, 0.8 0.5 mm diameter) corresponding to the radicular thirds (cervical, middle and apical) to be tested. The plunger tip was sized and positioned to touch only the post, without stressing the surrounding dentin, in an apical coronal direction to push the post toward the larger diameter, thus avoiding any limitation to the post movement possibly owing to the canal taper. This way, it was guaranteed that the dentin was sufficiently supported during the loading process.

The maximum failure load was recorded in Newton and converted into MPa. The bond strength was calculated from the recorded peak load divided by the computed surface area (A) as calculated by the following formula [19].

[A = (3.14x r1X 3.14x r2) L],

Where

r1 apical radius, r2 coronal one,

L (load)= [(r1-r2)2+h2]0.5

and h is the thickness of the sample in millimeters.

Failure was manifested by extrusion of the post and confirmed by sudden drop along load-deflection curve recorded by Bluehill Lite computer Software from Instron®. The push-out bond strength was calculated for each root specimen.

Smear layer evaluation

Two teeth as a representative of each subgroup were split longitudinally along the labio–lingual surfaces after irrigation. Each of the 12 specimens was examined using a scanning electron microscope (Model Quanta 250 Field Emission Gun attached with Energy Dispersive X-ray Analyses, with accelerating voltage 30 K.V., magnification14x up to 1000000 and resolution for Gun.1n) at 1, 4.5, and 8mm levels from the apical to the coronal third of the post space at 1000 magnification.

The amount of debris was observed at 1000 magnification and was marked from 0 to 2, as follows: (Gu et al. 2009) [20]

Mark 0: no debris particles

Mark 1: a few debris particles, with maximum diameter of less than 20 microns

Mark 2: large amounts of debris particles, with diameter greater than 20 microns in any direction.

Data were recorded, tabulated and statistically analysed.

RESULTS

Data analysis was performed in several steps. Initially, descriptive statistics for each group results. Three-way ANOVA was done to detect effect of each variable (irrigation solutions, application techniques & radicular regions). One way ANOVA followed by pair-wise Tukey's post-hoc tests were performed to detect significance between application techniques. Chi square test was performed between smear layer marks. Histograms and charts were made using Microsoft excel. Statistical analysis was performed using Asistat 7.6 statistics software for Windows (Campina Grande, Paraiba state, Brazil). P values ≤0.05 are considered to be statistically significant in all tests.

Push-out bond strength test results

The mean values and standard deviation of push-out bond strength test results for both irrigation groups as function to application techniques and

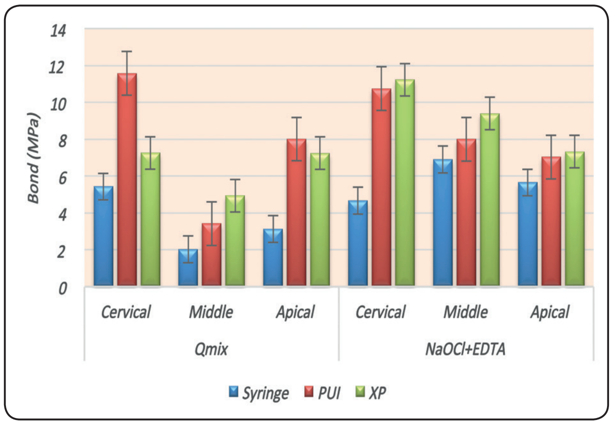

Fig. (2) Histogram of the mean values of push-out bond strength for both irrigation groups as function of application techniques and radicular regions

radicular regions were summarized in table (1) and graphically drawn in figure (2).

Effect of irrigation solutions on push-out bond strength

Regardless of application techniques or radicular regions, totally there was non-significant difference between both irrigation solutions as proven by three-way ANOVA test (F=3.08, P= 0.1046>0.05) where (***NaOCl + EDTA ≥ Q mix)***

Effect of application techniques on push-out bond strength

Irrespective to irrigation solutions or radicular regions, totally there was significant difference between application techniques as demonstrated

TABLE (1) Push-out bond strength results (Mean values± SDs) for both irrigation groups as function of application techniques and radicular regions

Variable		***Q mix***			***NaOCl+EDTA***		
		Cervical	***Middle***	***Apical***	***Cervical***	***Middle***	***Apical***
***Application* technique**	***Syringe***	5.43^{B}±0.38	2.03^{B}±0.47	3.13^{B}±0.72	4.66^{B}±0.49	6.89^{A}±1.2	5.65^{A}±0.96
	PUI	11.57^{A}±2.1	3.42^{AB}±0.51	8.01^{A}±1.2	10.74^{A}±3	7.99^{A}±2.4	7.03^{A}±1.6
	XP	7.26^{B}±2.2	4.93^{A}±0.66	7.25^{A}±1.6	11.23^{A}±1.4	9.39^{A}±1.6	7.32^{A}±1.9
Statistics	***P value***	0.0174*	0.0117*	0.0386*	0.0456*	0.2427 ns	0.5862 ns

Different letter in the same column indicating statistically significant difference (p < 0.05) ****; significant (p < 0.05)***
ns; non-significant (p>0.05)

by three-way ANOVA test (F=4.6, P=0.0412 <0.05) where (***PUI ≥ XP > Syringe)***. Pair-wise Turkey's post-hoc showed non-significant (P >0.05) difference between (***PUI*** and ***XP)***

Effect of radicular regions on push-out bond strength

Regardless of irrigation solutions or application techniques; totally there was non-significant difference between radicular regions as verified by three-way ANOVA test (F=2.4, P= 0.1428 >0.05) where (***cervical ≥ apical ≥ middle)***

Smear layer evaluation

The amount of debris observed at 1000 magnification by S.E.M at cervical, middle and apical regions for all the 6 subgroups was marked as shown in table (2)

Effect of irrigation solutions on smear layer marking

Regardless of application techniques or radicular regions, totally there was non-significant difference between both irrigation solutions as proven by Chi square test (Chi=2.5, P= 0.9271>0.05) where (***NaOCL+EDTA ≥ Qmix)***.

Effect of application techniques on smear layer marking

Irrespective of irrigation solutions or radicular regions, totally there was non-significant difference between irrigation application techniques as demonstrated by Chi square test (Chi=2.7, P= 0.9511>0.05) where (***Syringe ≥ PUI≥ XP)***.

Effect of radicular regions on smear layer marking

Regardless of irrigation solutions or application techniques, totally there was non-significant difference between radicular regions as verified by Chi square test (Chi=3.19, P= 0.9218>0.05) where (***apical ≥ middle ≥ cervical)***.

For Group I subgroup (A) "Syringe Irrigation with NaOCl + EDTA"

The surfaces of the specimens were covered with a heavy smear layer and large amounts of debris particles along the entire post space. (Fig 3)

For Group I subgroup (B) "PUI with NaOCl + EDTA"

More smear layer and debris were present at the apical region compared to the cervical and middle regions.

For Group I subgroup(C) "XP Finisher activated Irrigation with NaOCl + EDTA"

The smear layer was removed at the cervical region while at the middle and apical regions a few debris particles remained. (Fig 4)

For Group II subgroup (A) "Syringe Irrigation with Q mix"

The smear layer was removed at the cervical region while at the middle and apical regions a few debris particles remained

For Group II subgroup (B) "PUI with Q mix"

The smear layer was removed at the cervical and middle regions but few debris particles remained at the apical region.

TABLE (2): Smear layer marks at the cervical, middle and apical regions of the different subgroups

Variable		*Qmix*			*NaOCl+EDTA*		
		Cervical	*Middle*	*Apical*	*Cervical*	*Middle*	*Apical*
Application method	*Syringe*	0	1	1	2	2	2
	PUI	0	0	1	1	1	2
	XP	0	0	0	0	1	1

For Group II subgroup (C) "XP Finisher activated Irrigation with Q mix"

The smear layer and debris were completely removed along the entire post space with open dentinal tubules and areas of dentine erosion especially at the middle region. (Fig 5)

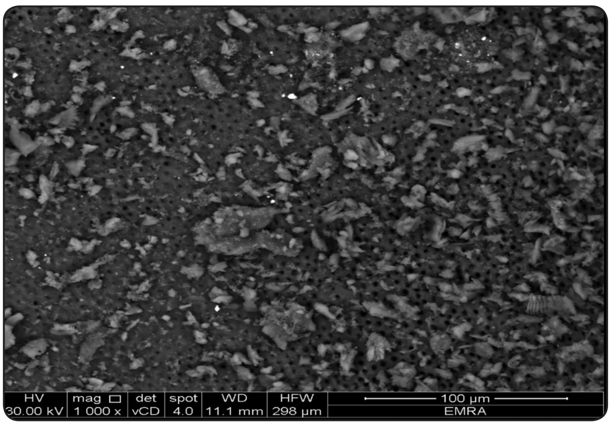

Fig. (3) SEM photomicrograph showing a heavy smear layer and large amounts of debris particles covering the radicular dentine

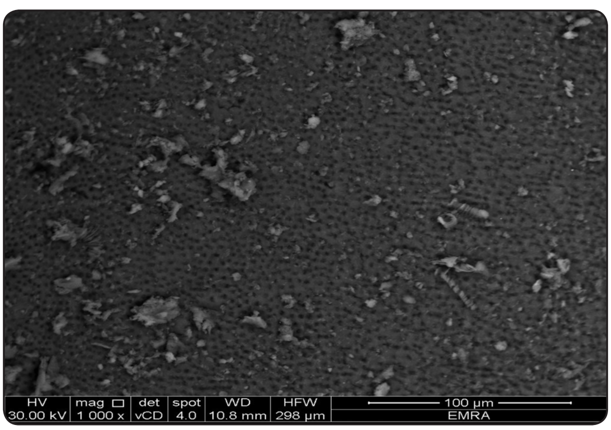

Fig. (4) SEM photomicrograph showing few debris particles covering the middle and apical dentinal regions

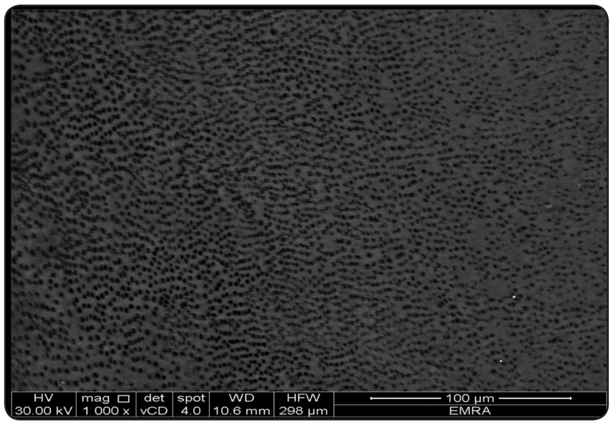

Fig. (5) SEM photomicrograph showing completely removed smear layer, open dentinal tubules and areas of dentine erosion

DISCUSSION

Currently, several application techniques are available, and reported to improve the final irrigation after post space preparation for smear layer removal such as the new instrument the XP-Endo finisher file and passive ultrasonic irrigation. These techniques are different in their theory and way of application.

Previous researches have found that the use of EDTA in combination with NaOCl irrigation for smear layer removal was effective.[21] A 1-minute 17% EDTA irrigation ensured adequate elimination of the smear layer, but the application of EDTA for more than1 minute could result in excessive dentinal erosion.[22]

Chlorohexidine has been used as a post space irrigant because of its antimicrobial effects, substantivity and biocompatibility.[13,23] Another reason to use Chlorohexidine for post space irrigation is the inhibition of the enzyme matrix metalloproteinase which may lead to decomposition of the hybrid layer and decalcification of the root canal dentin.[24]

Therefore, the aim of our study was directed towards evaluating the effect of different irrigation materials (Naocl + EDTA and Qmix) and application techniques (syringe, passive ultrasonic irrigation , XP finisher) on the push-out bond strength of fiber posts to root dentin.

Concerning fiber post cementation; adhesive luting inside the root canal is still challenging because of anatomic variability of the root canal dentin,[25] limited visibility, difficult moisture and application control and the high C-factor which might affect durable and stable bonding.[26,27] Consequently, adhesive luting of posts inside the root canal should be as simple as possible.

The most simplified adhesive strategy involves the use of self-adhesive resin cement, which has been used in this study, where no previous application of bonding agent is required. This cement has acid-functionalized monomers, such as 4-methacryloxyethyl trimellitic anhydride and pyromellitic glycerol dimethacrylate or phosphoric acid groups, such as 2-methacryloxyethyl phenyl hydrogen phosphate, 10-methacryloyloxydecyl dihydrogen phosphate, bis (2-methacryloxyethyl) acid phosphate, and dipentaerythritol pentaacrylate monophosphate, in their composition to allow bonding to the tooth substrate.[28]

As a consequence of the mixing process of self-adhesive resin cements, a pH value ranging between 1.5 and 3 will be created by the acidic monomers which will demineralize the dentin.[28] These acidic groups then will bind to calcium in the hydroxyapatite to form an ionic attachment between the methacrylate network and dentin. Ions released from the acid soluble filler will neutralize the remaining acidic groups to create a chelate-reinforced three-dimensional methacrylate network. Therefore, these materials become more hydrophobic during the polymerization process[28] and, it has been speculated that these products would be less prone to hydrolytic degradation than etch-and-rinse systems and self-etch adhesive systems. A recent meta-analysis[29] showed positive effects of the use of self-adhesive resin cements for luting fiber posts inside the root canal compared to other adhesive strategies. Especially for less experienced operators, the use of this simplified self-adhesive technique seems to be advantageous.[30]

In this study, push-out test was used to evaluate the bond strength between fiber posts and root dentin. Push-out test was utilized for bond strength testing in 75% of literatures published from 2007 to 2016 as it provides a practical tool for evaluating the interfacial shear strength between fiber post and root canal walls as an indicative to the retention of the fiber post in root canal. It has the benefit of more closely simulating the clinical condition as it mimics the forces that act on the post in the apico-coronal direction. [31] .In addition, this test is easy to perform and has less cohesive failures and smaller standard deviation [32]. Push-out tests also showed a more homogeneous stress distribution by finite element analysis.

The results of the current study showed that regarding the irrigation solutions, there was no statistically significant difference in the push-out bond strength values between the two irrigation solutions (NaOCL+EDTA and Q mix), with a higher bond strength value being in the NaOCL+EDTA group. This may be attributed to the dentin erosion caused by Q mix solution which was confirmed by the SEM photomicrographs that showed completely removed smear layer with open dentinal tubules and some areas of dentine erosion especially when Q mix was used in conjunction with the XP finisher. It has been assumed that when using self adhesive system, the complete removal of the smear layer and opening of dentinal tubules is not recommended as they bond to the superficial layer of dentin via the smear layer. [33] These results were in accordance with Kermansahah et al 2017[33]. However, they were opposed by Elnagy 2014[34] who found that Q mix gave a higher bond strength.

The previous assumption may also explain the higher bond strength values of NaOCL+EDTA over Q mix due to the incomplete dissolution of the smear layer when using NaOCL followed by EDTA as the self adhesive bond depends on the interaction between monomeric group and hydroxyapatite and the micromechanical retention. This was in accordance with Kul et al 2016[35].

Regarding the application techniques, results showed that passive Ultrasonic irrigation and XP finisher gave a statistically significant higher push-out bond strength values when compared to conventional syringe irrigation. This may be due to the presence of thick smear layer in the conventional syringe irrigation group which adversely affects the bond strength. The use of passive Ultrasonic irrigation and XP finisher induced a normal smear layer which is suitable for proper bonding. This was in disagreement with Gu etal 2009[36] who found that the additional use of irrigant activation techniques seems to be not advantageous for post space cleaning.

Regarding the effect of radicular regions on push-out bond strength, there was non significant difference in the push-out bond strength values between the different radicular regions. However, it was noted that the conventional syringe irrigation with NaOCl +EDTA showed lower bond strength values in the cervical region. This might be due to the action of the syringe, where the solution is pushed from the tip of the end vented needle rendering it more effective on the middle and apical regions than the cervical one. On the other hand the use of PUI and XP finisher with NaOCl + EDTA showed higher bond strength values in the cervical region. This may be related to the placement of the ultrasonic tip or XP finisher inside the root canal while it is already filled with the irrigant, so the irrigant would move upwards and become more accumulated coronally making it more effective at this region.

While for the Q mix group, it was noticed that the middle region showed lower push-out bond strength values when compared to the cervical and apical regions. This might be attributed to the presence of erosion areas in the middle region as confirmed by SEM images and this finding needs further investigations.

According to the previous discussion, the first null hypothesis that there would be no difference in the push-out bond strength between fiber posts and root canal dentin when using different irrigation materials and application techniques was rejected, as there was a significant difference between application techniques (Passive ultrasonic irrigation and XP showing higher bond strength values compared to syringe irrigation). While the second null hypothesis that different root regions would exhibit similar bond strength values was accepted.

CONCLUSIONS

Within the limitations of this study,it was concluded that:

1- Q mix irrigation solution decreased the bond strength between root dentin and fiber posts when self adhesive luting agent was used.

2- The use of XP finisher and passive ultrasonic irrigation as irrigant activation devices improved the bond strength between root dentin and fiber posts compared to conventional syringe irrigation.

RECOMMENDATIONS

1- In case of fiber posts, PUI and XP are preferably used over conventional syringe irrigation

2- In case of using self adhesive systems, Q mix irrigation solution is not recommended

3- Further investigations should be done to illustrate the reason for the lower push-out bond strength values in the middle region compared to the cervical and apical regions when using Q mix solution.

4- Clinical studies are recommended to confirm our in vitro results.

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