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EFFECT OF DIFFERENT POST SPACE IRRIGATION SOLUTIONS ON THE BOND STRENGTH OF TWO TYPES OF POST RESTORING ANTERIOR TEETH (INVITRO STUDY)

Sameh Abou-Steit*, Faten Ghonimy**, Marwa Salem*** *and* Heba Badra**

ABSTRACT

Aim: To evaluate the effect of different irrigation solutions on the bond strength of two types of post restoring anterior teeth.

Methodology: In this study, 24 extracted human maxillary incisors were collected according to the inclusion criteria. The crowns were cut off coronal to the cemento- enamel junction (CEJ) by 2 mm. Root canals were treated and prepared to receive irrigating solution and the posts. Teeth were then divided into 4 equal groups (n = 6) according to the irrigation and post used: group SP: received saline irrigation and PEEK post, group ER: received EDTA (Ethylenediamine Tetraacetic Acid) irrigation and Ribbond post, group EP: received EDTA irrigation and PEEK post. After mounting the teeth in acrylic blocks, each root was cut into a coronal, middle, and apical segments, perpendicular to its long axis. The push-out test was then performed on the samples using a universal testing device.

Results: It was revealed that group R (Ribbond post) and group P (PEEK post) had insignificant difference between them in their bond strength in coronal section, middle section, and in apical section when using different irrigating solutions.

Conclusion: PEEK posts demonstrated comparable bond strength values to Ribbond posts, with the latter having slightly superior results. When both types of posts were used, EDTA performed better than saline solution at cleaning the post space. The coronal and middle sections of the root canal presented better bond strength values when compared to the apical section.

KEYWORDS: PEEK, fiber-reinforced posts, Ribbond, irrigation solutions, bond strength.

* Lecturer, Department of Fixed Prosthodontics, School of Dentistry, Newgiza University, Cairo, Egypt.
** Assistant Professor, Department of Endodontics, Ahram Canadian University, Cairo, Egypt.
*** Lecturer, Department of Fixed Prosthodontics, School of Dentistry, Newgiza University, Cairo, Egypt.

INTRODUCTION

Restoration of teeth that have undergone endodontic treatment is a continuous area of debate due to the multiple challenges that clinicians encounter daily. Proper management of such cases requires the evaluation of many factors including: the sound tooth structure remaining, position of the tooth in the arch, type of restoration and the adhesive bond between the restoration and the natural tooth structure.

When the amount of sound natural tooth structure left is critical, a post and core followed by a final restoration is the optimum solution. [1-2] There are three types of post construction techniques: prefabricated, custom-made, and customized post with resin composite core. [3,4]

In recent years, there is increasing interest in the preservation of remaining tooth structure during radicular preparation with the use of adhesive non-metallic post systems such as glass fiber posts, fiber-reinforced posts and polyethelene PEEK posts. [3]

Glass fiber posts are clinically favorable due to the simple preparation technique, that, when combined with the adhesive cementation, results in higher bond strength. This is reflected as improvement in the clinical prognosis of these cases in terms of biomechanical behavior under stress and minimizing the risk of root fracture. [5]

Ribbond has been utilized effectively for several clinical treatments, including tooth splinting, and replacing lost teeth, strengthening of provisional restorations, and as a post system to retain the lost coronal part of the tooth. [4, 6, 7]

In addition, polyethylene fiber posts are suggested for the restoration of root canal treated teeth. It results, after adhesive cementation with resin cement to the radicular dentin, in the formation of a monoblock effect which increases the long-term success of these restorations along with improvement in esthetics and function. [8]

On the other hand, better stress distribution is provided by a custom-made post and core system than by a prefabricated glass fiber post, as the latter has multiple interfaces with different modulus of elasticity. [9,10] Therefore, a custom-made post and core composed of milled polymer polyetheretherketone (PEEK) resin had good dimensional stability, biocompatibility, was simple to polish, and was machinable. [11- 13] Consequently, adhesive failures are decreased, and the post/core system is shielded against premature fracture. [9]

During the rehabilitation of non-vital teeth, it's necessary to choose a post system able to achieve high bond strength with the cement as well as with the radicular dentin. Any filling material residues left after post space preparation, could have a negative impact on this process. [6-9] To ensure thorough cleaning of the canal, several dentin surface cleaning solutions are suggested, including sodium hypochlorite (NaOCl), ethylenediamine tetraacetic acid (EDTA), and chlorhexidine gluconate. In the literature, it is unclear what happens to them after post space preparation, even though their usefulness and potency during root canal preparation are well established. [14,15]

It is of great importance to determine the effect of various cleaning protocols on the bond strength with different types of posts to ensure good adhesion after cementation. [16-19]

Therefore, the aim of this study was to evaluate the effect of different irrigation solutions on the bond strength of two types of post restoring anterior teeth.

The null hypothesis was that there would be no significant difference between different post space irrigation solutions on the bond strength of two types of posts (PEEK and Ribbond) restoring anterior teeth.

MATERIALS AND METHODS

The study had been approved by the Research Ethics Committee, faculty of Dentistry, Cairo University (approval # 2612023)

Samples grouping

A total of 24 maxillary central incisors were collected and then randomly divided equally into 4 groups according to: the type of irrigation material and the post used. Group SR: received saline irrigation and Ribbond post, group SP: received saline irrigation and PEEK post, group ER: received EDTA (Ethylenediamine Tetraacetic Acid) irrigation and Ribbond post and group EP: received EDTA irrigation and PEEK post.

Teeth selection and preparation

Freshly extracted maxillary central incisors, with intact crowns, were collected for this study from the Department of Oral and Maxillofacial Surgery at Newgiza University and Ahram Canadian University.

The inclusion criteria were complete root formation, absence of root caries or root fractures. To standardize the dimensions of the selected teeth, the crown was cut off coronal to the cemento-enamel junction (CEJ) by 2mm. Root faces were then flattened using a high-speed wheel stone. Then a digital caliper (Mitutoyo IP 65, Kawasaki, Japan) was used to measure the tooth dimensions MD and BL at the CEJ with maximum deviation in dimension of 10%. Before implementing any intervention, each tooth was immersed in (5.25%) NaOCl for surface disinfection and periodontal ligament removal followed by storage in distilled water until use.

Root canal treatment

Root canal treatment was done using crown-down technique utilizing rotary M-Pro nickel-titanium instruments (IMD Company) following the manufacturer's instructions up to #35 instrument. The M-Pro system was connected to an endodontic micro-motor X-Smart (X-Smart, Dentsply-Maillefer, Ballaigues, Switzerland). Each root canal was irrigated with 2 ml of 5.25% sodium hypochlorite (NaOCl) at each file size by means of a 27-gauge needle. After finishing root canal preparation, irrigation of each canal was performed with 5ml of 17% ethylenediaminetetraacetic acid (EDTA) for 60 seconds. Lateral condensation technique along with resin sealer were used during obturation (ADSEAL, Meta Biomed Co., Korea).

Afterwards, a universal bonding agent (All-bond universal, Bisco, USA) was placed, and light cured for 20 second to achieve an optimum coronal seal. Then, flowable composite (3M filtek supreme flowable composite, 3M, USA) was placed and light cured. Later, to ensure proper setting of the resin sealer, teeth were preserved in 0.9 % saline solution in a clean glass container which was preserved in an incubator at 37° C for one week.

Post space preparation

Intra-canal preparation was accomplished using Gates Glidden (Mani, Italy) followed by FiberKleer fiber post drills (pentron clinical, USA) in sequential order (size 1-2-3) to remove gutta percha and prepare the radicular post space consecutively. To achieve a minimum of 3 mm gutta percha apical seal, all rotating instruments, inserted into the root canal, were mounted on a low-speed handpiece, and set to a standard length of 10 mm.

For all the groups, post spaces of all canals, were irrigated with either 10 ml saline or EDTA (according to the group) for 60 seconds by means of a 27-gauge needle of plastic syringe and were cleaned with 5 mL of distilled water and dried with absorbent paper points to be ready for post placement.

Ribbond post fabrication and bonding (Group SR, ER) (Figure 1)

Ribbond was cut off at length (10 mm) by its special scissor and was placed after injecting the root canals by self-adhesive resin cement (BisCem, Bisco, USA) using the endo tip in an apical to coronal direction. To guarantee that the post was

completely covered in resin cement, endodontic plugger was used. Light curing of resin cement was performed after placement of post for 20 seconds.

The root face was next treated with universal bonding agent (All-bond universal, Bisco, USA), which was then light cured for 20 seconds. A coronal seal was subsequently created by injecting flowable composite all the way around the post and curing it for 20 seconds. Then, to ensure that the resin cement completely set, the teeth were placed in a clean glass container with 0.9% saline solution, which was then kept in an incubator at 37°C for a week.

PEEK post construction (Group SP, EP) (Figure 2)

CAD/CAM PEEK posts were fabricated using intra-oral scanner (Medit T 710, Medit, Korea) to scan the prepared post space inside the root canal. The exocad software (3.0 Galway) was used for designing of the PEEK posts and milling machine (Arum 490) was used for milling of the posts (Figure 2). Sprues were sliced and finished with diamond finishing stones after the posts had been milled. After inspecting the posts inside the root canal, visio.link primer (Bredent, USA) was applied, and then bonding with the resin cement was improved by sandblasting the posts and curing them in a bench top light polymerization device for 90 seconds.

Sample preparation for the push out test

A dental conveyor (BEGO GmbH and Co. KG, Germany) was used to mount teeth in acrylic resin blocks. Samples were then cut off at a right angle to their long axes using a precision saw (IsoMet 4000, Buehler, USA). Each root yielded three post/dentin sections of 2mm thickness: coronal, middle, and apical. A permanent marker was used to color code the samples based on their sectioning position. Then the thickness of the samples was checked using a digital caliper.

The push out test

A push-out jig was used to lock all samples into position. This was done after ensuring that the coronal surface of each sample faced the loading fixture, and the post was centered in the hole. The push out test was performed by applying a compressive stress to the apical aspect of each slice using a cylindrical punch (plunger) with a diameter of 1.2 mm installed on a universal testing machine (Instron 3345, INSTRON, USA). The tip was positioned so that it would only contact the post's surface and not the cement or canal walls close by. The load was applied to the apical surface of the samples with a crosshead speed of 1 mm/min in an apico-coronal direction (toward the larger

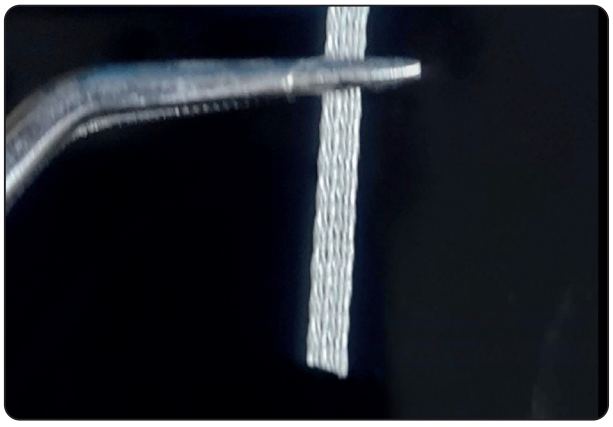

Fig. (1): Polyethylene Fibre Ribbond

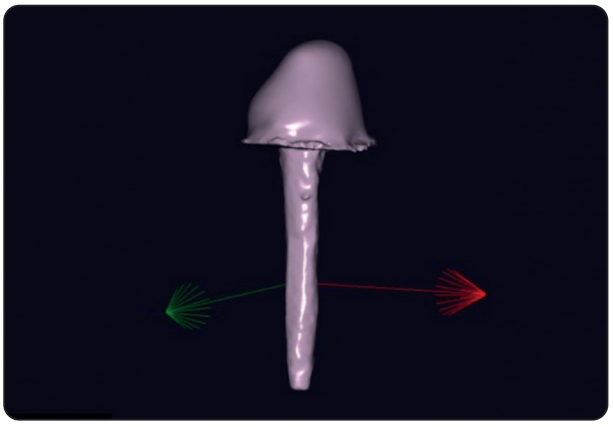

Fig. (2): Fabricated PEEK post using exocad software.

Fig. (3): Universal testing machine

area of the root section) until bond failure occurred, which was indicated by the protrusion of post segments from the root. (Figure 3)

A computer program was used to record the highest load before the post was forced to separate from the tested sample (the debonding force), which was then converted from Newton (N), the unit used to measure bond failure, to megapascals (MPa). Utilizing IBM SPSS 20, GraphPad Prism, and Microsoft Excel 2016, statistical analysis was carried out. Standard deviation and mean were used to represent the data.

RESULTS

- Comparison between group R (Ribbond posts) and group P (PEEK posts) revealed insignificant difference between them in their bond strength in coronal section (P=0.25,0.19), middle section (0.10, 0.24), and in apical section (0.06,0.12) when using different irrigating solutions (Table 1 and Figure 4).
- Comparison between different sections was performed by using One Way ANOVA test which revealed that: (Table 2, Figure 4)

• The coronal section was significantly the highest, then middle section while apical section was significantly the lowest, regarding ER, EP and SP groups.

• In SR group, apical section was significantly the lowest, while there was insignificant difference between coronal and middle sections.

• Comparison between different irrigating solutions revealed that EDTA groups was significantly higher than saline groups regarding all section of group R & P as P>0.05.

TABLE (1) Comparison between Push out strength of group R & P posts using independent t test

		Group R (Ribbond)		Group P (PEEK)		Difference				
						MD	SED	95% CI		P value
		M	SD	M	SD			Lower	Upper	
Group E (EDTA)	Coronal	15.54	0.55	15.26	0.13	0.28	0.23	-0.23	0.80	0.25 ns
	Middle	13.79	0.66	13.15	0.53	0.64	0.35	-0.14	1.41	0.10 ns
	Apical	7.71	0.95	6.57	0.94	1.14	0.55	-0.07	2.35	0.06 ns
Group S (saline)	Coronal	13.75	0.86	13.20	0.41	0.55	0.39	-0.32	1.41	0.19 ns
	Middle	12.56	0.70	12.14	0.43	0.42	0.33	-0.33	1.16	0.24 ns
	Apical	5.01	0.92	4.26	0.56	0.75	0.44	-0.23	1.73	0.12 ns

M: mean ***SD: standard deviation*** ***MD: mean difference*** ***SED: standard error of difference.***

CI: confidence interval ***L: lower arm*** ***U: upper arm***

Ns: non-significant difference as P>0.05.

TABLE (2) Comparison between E (EDTA) and S (Saline) groups using Paired t test, and comparison between different sections using One Way ANOVA test

Push out Bond Strength (Mpa)						Difference				
Group	Section	E (EDTA)		S (saline)		MD	SEM	95% CI		P value
		M	SD	M	SD			L	U	
Group R (Ribbond)	Coronal	15.54 a	0.55	13.74 a	0.86	1.79	0.42	0.86	2.72	0.002 *
	Middle	13.79 b	0.66	12.56 a	0.70	1.23	0.39	0.35	2.10	0.011*
	Apical	7.71 c	0.95	5.013 b	0.92	2.69	0.54	1.49	3.89	0.001*
	P value	<0.0001*		<0.0001*						
Group P (PEEK)	Coronal	15.25 a	0.13	13.20 a	0.41	2.06	0.18	1.66	2.45	0.0001*
	Middle	13.15 b	0.53	12.14 b	0.43	1.01	0.28	0.39	1.63	0.005*
	Apical	6.56 c	0.94	4.26 c	0.56	2.31	0.45	1.31	3.30	0.0001*
	P value	<0.0001*		<0.0001*						

M: mean ***SD: standard deviation*** ***MD: mean difference*** ***SED: standard error of difference.***
CI: confidence interval ***L: lower arm*** ***U: upper arm*** ****Significant difference as P<0.05***
Means with different superscript letters per column were significantly different as P<0.05.
Means with the same superscript letters per column were insignificantly different as P>0.05.

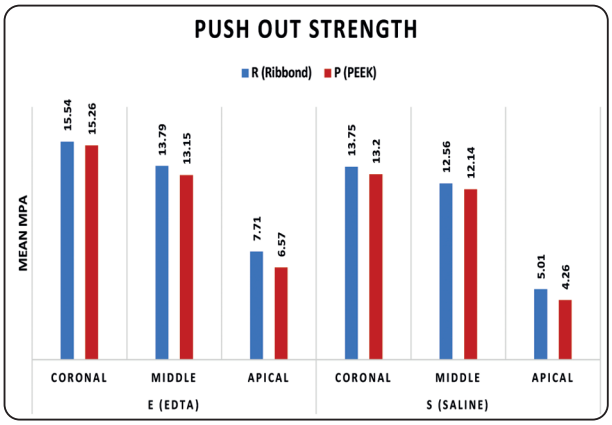

Fig. (4) Bar chart showing push out strength of both groups at EDTA and saline regarding all sections.

DISCUSSION

Endodontically treated teeth must be restored with the suitable type of post because, in most cases, the remaining coronal tooth structure becomes thin due to caries, access cavity preparation, root canal preparation, and endodontic treatment. The post in this situation provides retention for the final restoration. [13] Furthermore, the use of posts necessitates the removal of more tooth structure, increasing the risk of tooth fracture. [14] Therefore, to create a monoblock effect that increases the tooth's resistance to fracture, the use of post material with an elastic modulus closer to that of the tooth dentine and the post's ability to bond to dentine and resin cement are both essential. [17,20]

All materials utilized and investigated in the current study were used following the manufacturer's instructions. [18] Because eugenol-containing sealers could affect resin cement's polymerization and interfere with its ability to adhere, ADSEAL resin sealer was employed. [19]

When preparing the post space in teeth that have had endodontic treatment, gutta-percha and sealer must be removed. These residues cause smear layer and debris to form on root canal walls, which may obstruct dentinal tubules. [21,22] The presence of resin tags and micromechanical retention caused by the demineralized radicular dentine surface served as evidence for the adhesiveness of fiber

posts and resin luting agents to the radicular dentin. Therefore, failure to remove the smear layer reduces the bonding of any adhesive protocol to the canal walls which causes weak adhesion of smear layer to radicular dentine. [23,24]

The push-out test findings showed that PEEK and Ribbond posts have comparable bond strength with the root dentine in terms of the coronal, middle and apical root thirds, with the Ribbond post having slightly superior results but not significantly different. In addition, there was significant difference between EDTA and saline post space irrigation solutions on the bond strength of the two types of posts to root canal dentin, therefore, the null hypothesis was (partially) rejected.

Considering the comparable bond strength of PEEK and Ribbond posts, this might be explained by the semi crystalline structure of Ribbond which contains fillers embedded in resin matrix that improve the bond strength with the resin cement and root dentin. Additionally, custom-made PEEK's polymer basis gives it good adaptability to tooth structure, which has led to a reduction in resin cement's film thickness, decrease in polymerization shrinkage stress and improvement in the bond strength value. [18,19] The results can also be explained by the PEEK posts' low elastic modulus, which results in a reduced stress distribution profile along the root interface compared to glass-fiber posts. [25]

In accordance with our findings, Monteiro et al. found that there is no difference between the bond strength values of PEEK and Ribbond posts within root canal thirds when endodontic treatment remnants are properly removed, and the bonding procedure is used following the manufacturer's instructions. [26]

Furthermore, no irrigation solution has been able to dissolve both the organic and inorganic components of the smear layer until now. Irrigation's primary goal is to remove dirt and the smear layer. [24] Several irrigants, including 17% EDTA and 5.25% NaOCl, have been investigated and shown to be effective previously. [23]

Regarding the comparison between EDTA and saline as post space irrigation solutions, EDTA groups were significantly higher than saline groups regarding all sections of the root canal. This might be due to the organic composition of EDTA as a bivalent cationic material that selectively remove hydroxyapatite and non-collagenous dentin. This was very beneficial in endodontics as well as restorative procedures due to the chelating calcium ions as well as ability to remove smear layer. [27] Greater chemical interaction is presented by the adhesive functional monomer due to the low decalcification potential of the dentin surface. Also, deeper penetration of the resinous tags is provided when using EDTA solution as it allows a thin hybrid layer without collagen denaturation because of the remaining apatite crystals in the collagen matrix. [28] According to Gu et al., irrigation with EDTA for only one minute can successfully reduce the smear layer, while five minutes causes significant root dentin erosion. Therefore, groups irrigated with EDTA displayed greater bond strength than saline groups. [23]

In the current investigation, the group of saline solution had a substantially smaller impact on bonding strength than EDTA group. It was incapable of dissolving organic tissue and lacked chelating or antibacterial qualities. As a result, it was frequently used in conjunction with other root canal preparation solutions in endodontic therapy. [29] In contrast, saline solution had higher bond strength values than EDTA, according to Barreto et al. [30]

Comparing between different sections revealed that, the coronal level had better push-out bond strength than middle and apical level sequentially. This result was due the higher dentinal tubules density found in the coronal and middle thirds of the root canal than in the apical area, and decreasing in the tubular diameter in the apical direction. These

differences in tubules counts suggested that the coronal sections had the strongest adhesion. [31,32]

In this study, no mechanical stressing nor thermo-cycling of the samples were performed. While some authors showed no significant difference between the push-out bond strength of fiber posts before and after thermo-cycling and mechanical stressing, other research have shown that these characteristics may restrict the direct transfer of study results to clinical circumstances. [33, 34]

CONCLUSION

- PEEK posts demonstrated comparable bond strength values to Ribbond posts, with the latter having slightly superior results, indicating a trustworthy alternative for dental post systems.
- EDTA was better than Saline solution for cleaning of post space when using both posts type.
- The coronal and middle sections of the root canal presented better bond strength values when compared to the apical section of the root canal.

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