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COMPARISON OF BOND STRENGTH OF FIBER POSTS IN ROOT CANAL TREATED TEETH OBTURATED WITH TWO DIFFERENT SEALERS (AN INVITRO STUDY)

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ABSTRACT

Objective: Evaluation of the influence of two endodontic sealers on the push-out bond strength of fiber posts bonded by a self-adhesive resin cement.

Materials and methods: 42 premolars with average root length of 17±1 mm were chosen. Teeth were cut 2mm above the CEJ. Endodontic treatment was performed then teeth were distributed into 2 equal groups (n=16) as follows; **Group_1:** Teeth obturated by X4 gutta-percha and AdSeal sealer. **Group_2:** Teeth obturated by X4 gutta-percha and CeraSeal sealer. After 7 days, post-space preparation was done leaving 4-5 mm apical seal. Post space was rinsed with 5% NaOCl then 17% EDTA. Posts were salinized then bonded using Rely X U200 self-adhesive resin cement. Teeth were placed in epoxy-resin then sectioned perpendicular to the root long axis. 3 specimens 2mm thick were obtained corresponding to every root third. Push out test was done. Maximum load to failure was recorded in Newton(N) then converted into MPa. Five teeth were sectioned longitudinally following post space preparation and examined using (SEM) at 1000x.

Results: **Gr_1** recorded statistically significantly higher mean value compared to **Gr_2** as indicated by two-way ANOVA. **Apical region** group recorded statistically significant highest mean value followed by **middle region** group while **cervical region** group recorded statistically significant lowest mean value as indicated by two-way ANOVA. Pair-wise Tukey's post-hoc test showed non-significant difference between middle and apical regions.

Conclusions: Bioceramic sealers reduced the bond-strength between root dentin and fiber posts when self-adhesive luting agent was utilized.

KEYWORDS: Bioceramic sealer, resin sealer, resin cement, push out bond strength

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INTRODUCTION

Badly broken down pulpless teeth are brittle and possess little or no coronal tooth structure. This makes them more vulnerable than vital teeth. However, proper root canal treatment can turn them into useful members of the dental arch.

The restoration of endodontically treated teeth is essential, it impacts their long-term survival. In most cases, those teeth are accompanied with tooth structure loss from previous restorations, access cavity preparation, and caries. In cases, where a large amount of dentine has been sacrificed, it is impossible to have an adequate support for a restoration in the remaining amount of tooth dentine. That's why posts are essentially needed for endodontically treated teeth. **Uthappa et al. (2015)** [1]

Fiber posts with their many advantages have become a paramount restorative option for root canal treated teeth. Even though fiber posts are widely used, however, they are not fool-proof and restoration failures have been documented. **Kulkarni et al. (2016)** [2]

Failures in fiber posts are mostly because of debonding, improper posts' adaptation to root dentine, and polymerization shrinkage stresses of the luting cement. **Kalkan et al. (2006)** [3] Those failures typically happen at the interface of the canal wall and the resin cement. [4,5]. In fact, this interface is influenced by multiple factors including orientation of dentinal tubules, techniques and solutions used for irrigation, the adhesive system and the sealer used. [6,7]

Endodontic sealers are used during obturation. They are utilized to close gaps between dentine walls and gutta percha. During bonding of fiber posts, its retention might be influenced by the type of used sealer. [8]

Sealers are used to facilitate the seal of inaccessible lateral and apical accessory canals due to their flowability [9] and to offer a good adaptability to root canal dentin [10]. Bio ceramic sealers are more popular nowadays because they are able to bond to dentin by the creation of a hydroxyapatite layer and has a high flowability to enter and seal lateral and accessory canals. Bioceramic sealers are hydrophilic with an alkaline ph. They begin their setting process by using the moisture from the dentinal tubules. [11,12]

Resin sealer was used as a gold standard [13,14] as a result of its outstanding properties including sealing ability and adhesion [15,16]. Moreover, when fiber posts are bonded with resin cements, it doesn't affect the root dentin's bond strength. [17]

To date, there is insufficient evidence about the possible interference of bioceramic sealers with fiber posts bond strength to root dentin. Also, there is insufficient data about the effect of the hydroxyapatite layer formed during setting of bioceramic sealers on the bonding of fiber posts to root dentin. Therefore, the aim of our research was evaluation of the influence of two endodontic sealers (epoxy resin-based and bioceramic sealer) on the push-out bond strength of fiber posts bonded by a self-adhesive resin cement.

The null hypothesis was that the type of endodontic sealer will not have any influence on push-out bond strength between root dentine and fiber post.

MATERIALS AND METHODS

Sample size calculation

In a previous study by ElKhodary and Elbasty (2018), [18] the response within each subject group was normally distributed with standard deviation 0.49. If the true difference in the experimental and control means is 0.5 (cohen's d medium effect size), we needed to study 16 experimental teeth and 16 control teeth to reject the null hypothesis that the population means of the experimental and control groups are equal with probability (power) 0.8. The Type I error probability associated with this test of this null hypothesis was 0.05. Sample size was calculated using PS (Power and Sample size program), version 3.1.2 for windows using independent t test. [19]

Ethics approval:

The study protocol was approved by the Research Ethics Committee of Scientific Research, Faculty of Dentistry, Cairo University in October 2022 (Approval numbers: 23-10-22).

Teeth selection

Forty two single root canalled premolars with average root length of 17±1mm were chosen in our study (Ten of them used for the SEM evaluation). The teeth had no previous restorations, fractures, or cracks. They were stored in 0.1%chloramine T for 7 days then kept in distilled water and used within 3 months of extraction. A disc was used to cut the clinical crowns 2mm above the CEJ under copious cooling.

Endodontic treatment

Endodontic treatment for all teeth was performed by the same endodontist. A K file size 15 was used to confirm the working length by seeing the file tip from the root apex. The adjusted working length was 1mm away from the apical foramina. Canals were prepared with ProTaper next rotatory system (Dentsply-Maillefer, Switzerland) to size X4. 2 ml of 2.5 % NaOCl was used between each file and finally 17%EDTA was used for one minute (final rinse). Root canals then rinsed by distilled water for 1 minute. X4 paper-points were placed inside the canals to ensure dryness before obturation.

Teeth then distributed randomly into 2 equal groups (n =16) respective to sealer used as follows;

Group_1: Teeth obturated with X4 gutta-percha (META BIOMED CO.LTD, Korea) and AdSeal resin sealer (META BIOMED CO.LTD, Korea) using modified single cone technique.

Group_2: Teeth obturated with X4 gutta-percha cones using CeraSeal (META BIOMED CO.LTD, Korea) using single cone technique.

In both groups, an interim restoration was used to close the access (Coltsol F, Coltene, Switzerland) and teeth were kept in distilled water at 37˚C for 7 days.

Preparation of the post space

Appropriate size of NexPost glass fiber posts (META BIOMED CO.LTD, Korea) was selected, 1.5 mm diameter and 6% taper. Gates-glidden (Dentsply-Maillefer, Switzerland) were utilized to eliminate the gutta percha to a depth of 12 mm leaving 4-5 mm as a minimum apical seal.

NexPost tapered drill matching to the size of the fiber post was utilized for complete canal preparation at a low speed with a coolant. Post space was rinsed with 5ml of 5 % NaOCl then 5ml 17% EDTA then flushed by distilled water. Paper points then used to ensure dryness of the post space.

Post cementation

The selected posts were checked for fitting inside the canals before cementation. Then the posts were cleaned by alcohol then dried thoroughly. Rely X ceramic primer (3M ESPE Dental products, St. Paul,USA) was put on the posts and left for 1 minute then air dried.

Rely X U200 self-adhesive resin cement (3M ESPE Dental products, St. Paul,USA) was utilized for cementation of posts; first, Endo-tip was attached to mixing tip of the automix syringe then deeply applied in the created post-space to administrate the cement. Posts then placed in created post-spaces and kept stable in the space with moderate pressure. Any excess cement was taken out followed by light curing for 40 seconds.

Afterwards, the coronal part of the posts was sealed with resin- modified glass ionomer cement (Vitrebond Plus, 3M ESPE) and then teeth kept in distilled water 37˚C for 7 days.

Push-out test

Teeth were placed in epoxy resin then cut into sections perpendicular to the long axis of the root by a digital machine (Isomet 5000, Buehler, Lake Buff, USA). Three specimens 2mm thick were obtained using a diamond saw used under water coolant, where one specimen represented a root third (apical, middle, and cervical). Using a digital caliper, the thickness of all specimens was checked.

Specimens were marked from their coronal side by a permanent marker and then photographed from coronal and apical sides by a stereomicroscope (SZ-PT; Olympus, Tokyo, Japan) at a 65x magnification. Calibration was done by an object of a known length, a ruler, was compared using the "Set Scale" tool generated by the image analysis software (Image J; NIH, Bethesda, MD). This was followed by measuring the posts' diameter and calculating the radius.

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

The load was applied to posts in an apical-coronal direction by plungers with different diameters. Diameters were 1mm, 0.8mm and 0.5mm for the cervical, middle, and apical thirds respectively. The plungers' tips were checked to ensure absence of contact with dentine pushing the posts in the direction of the larger diameter.

The maximum load to failure was recorded in Newton (N) then converted into MPa. Bond strength was calculated from the recorded peak load that was divided by the computed surface area (A) according to the below formula. [20]

[A = (3.14x r1X 3.14x r2) L], Where
r1 apical radius, r2 cervical one,
L (load)= [(r1-r2)2+h2]0.5
and h is the specimen's thickness in mm.

Post extrusion served as a sign of failure and a sudden drop along load-deflection curve was recorded by Bluehill Lite computer Software from Instron as a confirmation to failure. For each root specimen, the push-out bond strength was determined.

SEM evaluation

Representing each group, five teeth were sectioned longitudinally after post space preparation. SEM (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) was used to examine 10 specimens at 1, 4.5 and 8mm levels from the apical to the cervical third of the post space at a magnification of 1000.

Data analysis

Results were analyzed by using Graph Pad Instat (Graph Pad, Inc.) software for windows. A value of P < 0.05 was considered statistically significant. Continuous variables were expressed as mean and standard deviation. One-way analysis of variance was used followed by Tukey's post-hoc test if showed significance. Student t-test was used for compared pairs. Two-way ANOVA compared the influence of each factor (root canal sealer type and radicular region). Sample size (n=16) was large enough to detect large effect sizes for main effects and pair-wise comparisons, with the satisfactory level of power set at 80% and a 95% confidence level.

RESULTS

Descriptive statistics of push-out bond strength results measured in (MPa) for both groups as function of radicular region including mean values and standard deviation (Mean ±SD) are shown in table (1) and figure (1).

For **Gr_1:** ***apical region*** subgroup reported statistically significant ($p < 0.05$) highest mean value (8.03±2.4 MPa) followed by ***middle region*** subgroup (7.61±1.4 MPa) while ***cervical region*** subgroup reported statistically significant ($p < 0.05$)

lowest mean value (5.59±1.96 MPa) as indicated by one way ANOVA test. Pair-wise Tukey's post-hoc test revealed insignificant difference regarding ***middle*** and ***apical*** regions ($p > 0.05$). (Table 1 and Figure 1)

For **Gr_2** ***apical region*** subgroup reported statistically significant ($p < 0.05$) highest mean value (6.74±1.3 MPa) followed by ***middle region*** subgroup (6.54±0.71 MPa) while ***cervical region*** subgroup reported statistically significant ($p < 0.05$) lowest mean value (4.98±1.27 MPa) as indicated by one way ANOVA test. Pair-wise Tukey's post-hoc test revealed insignificant ($p > 0.05$) difference regarding ***middle*** and ***apical*** regions. (Table 1 and Figure 1)

Group_1 vs. Group_2

Cervical region; **Gr_1** reported statistically insignificant ($p > 0.05$) higher mean value (5.59±1.96 MPa) than **Gr_2** (4.98±1.27 MPa) indicated by student t-test.

Middle region; **Gr_1** reported statistically significant ($p < 0.05$) higher mean value (7.61±1.4 MPa) than **Gr_2** (6.54±0.71 MPa) indicated by student t-test.

Apical region; **Gr_1** reported statistically insignificant ($p > 0.05$) higher mean value (8.03±2.4 MPa) than **Gr_2** (6.74±1.3 MPa) indicated by student t-test.

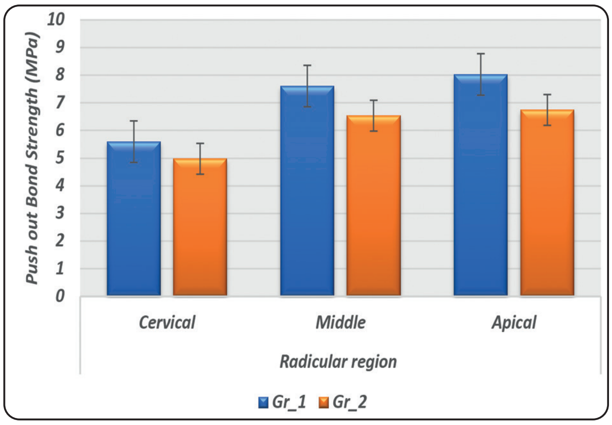

Fig. (1) Column chart of push out bond strength mean values comparing between both groups at different radicular regions

Irrespective of radicular region, totally **Gr_1** reported statistically significant ($p > 0.05$) higher mean value compared to **Gr_2** indicated by two-way ANOVA.

Regardless to experimental groups, totally, **apical region** group reported statistically significant ($p < 0.05$) highest mean value followed by **middle region** group while **cervical region** group recorded statistically significant ($p < 0.05$) lowest mean value as indicated by two-way ANOVA. Pair-wise Tukey's post-hoc test revealed insignificant ($p > 0.05$) difference between middle and apical regions.

TABLE (1) Push out bond strength results (Mean ±SD) for both groups as function of radicular region.

Variables		Radicular region			Statistics
		Cervical	Middle	Apical	P value
Gr_1	Mean ±SD	$5.59^{B}\pm1.96$	$7.61^{A}\pm1.4$	$8.03^{A}\pm2.4$	0.002*
	95% CI (Low-High)	4.64-6.56	6.92-8.294	6.88-9.18	
Gr_2	Mean ±SD	$4.98^{B}\pm1.27$	$6.54^{A}\pm0.71$	$6.74^{A}\pm1.3$	<0.0001*
	95% CI (Low-High)	4.36-5.6	6.19-6.88	6.12-7.36	
Statistics	P value	0.2964 ns	0.01*	0.0641 ns	

Different superscript letter in same row indicating significance between regions (p<0.05)
****; significant (p<0.05)   ns; no-significant (p>0.05)***

SEM Evaluation

For Groups 1 and 2:

SEM photomicrographs showed greater amount of opened dentinal tubules as we go apically (Figure 2, 3, 4)

Group_1 vs. Group_2:

Irrespective of radicular region, SEM photomicrographs for group 1 showed greater amount of opened dentinal tubules compared to group 2. (Figure 2, 3, 4)

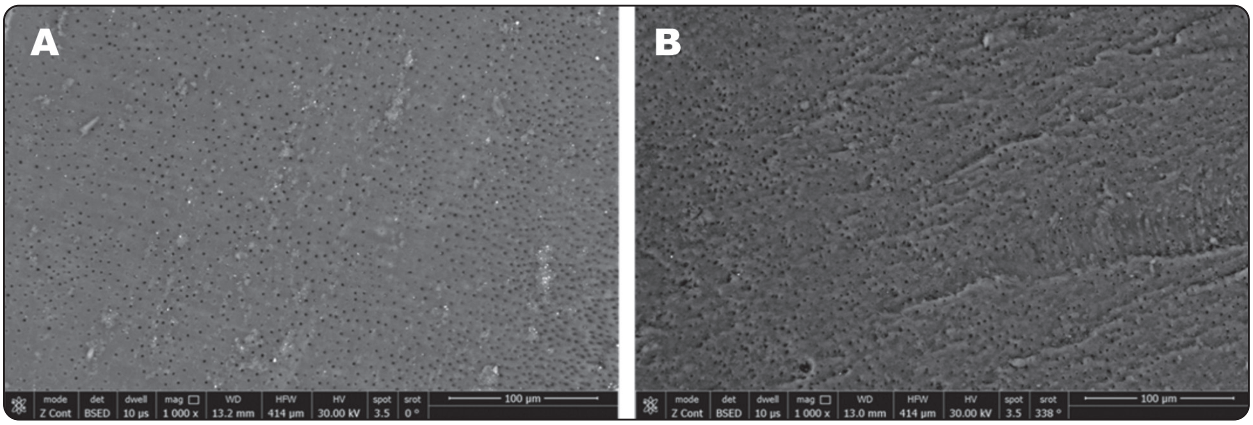

Fig. (2) a: SEM photomicrograph of the apical region for group 1, b: SEM photomicrograph of the apical region for group 2.

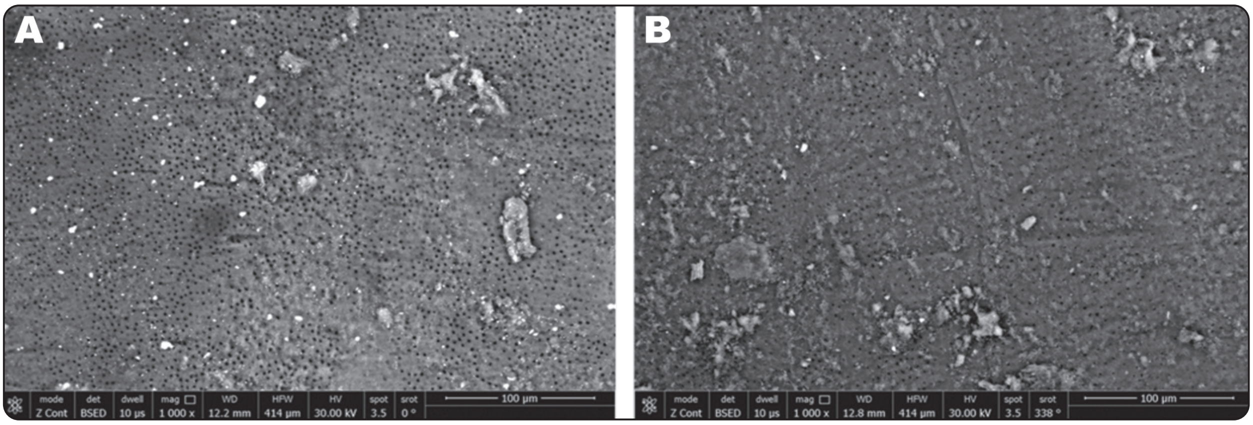

Fig. (3) a: SEM photomicrograph of the middle region for group 1, b: SEM photomicrograph of the middle region for group 2

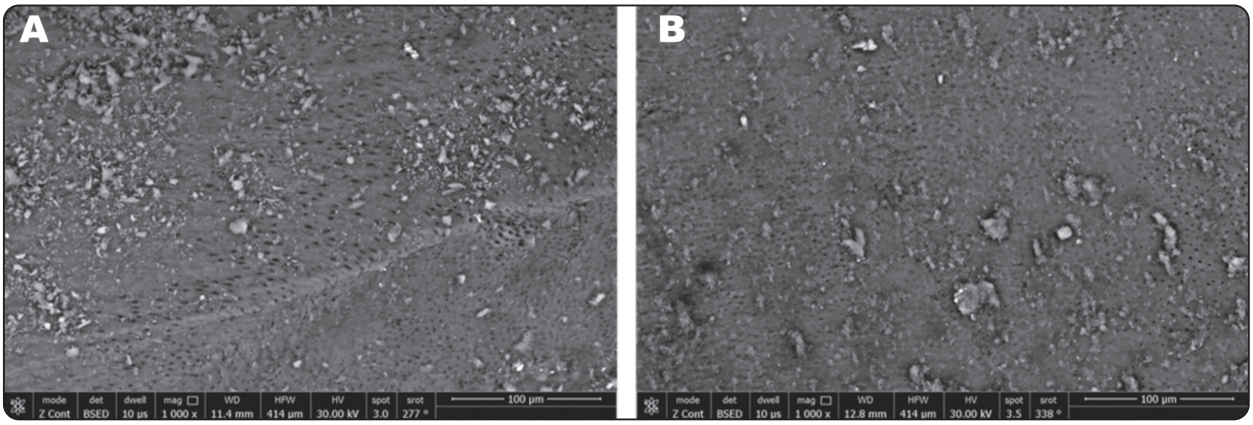

Fig. (4) a: SEM photomicrograph of the cervical region for group 1 b: SEM photomicrograph of the cervical region for group 2

DISCUSSION

Some endodontic aspects needs to be considered during cementation of fiber posts. Sealer utilized during obturation, the duration between obturation and cementation of post, and post space cleaning routine all have a role in the bond strength of the fiber post to root dentin. [21] Chemical composition of sealers affecting bond strength of glass fiber posts has been previously recorded. Ceraseal, was introduced as an endodontic bioceramic sealer which shows better sealing ability, better bonding to root dentine and better antibacterial activity compared to the conventional resin-based ones. [22] However, the influence of bioceramic sealers on the bond strength of fiber post is still a point of controversy. [22] Therefore, the aim of our study was evaluation of the influence of two endodontic sealers (epoxy resin-based and bioceramic sealer) on the push-out bond strength of fiber posts bonded by a self-adhesive resin cement.

In our study, human natural teeth were selected nearly equal in dimensions to simulate the clinical situation and prevent differences in root size from altering the results. Root canal treatment was carried out by same endodontist for standardization. Preparation of post space was done 7 days after obturation to confirm sealers' setting. [23] Previous studies showed insignificant difference in the bond strength if post was cemented immediately or after 7 days. [24]

Cleaning of post space was done using 5% NaOCl then 17% EDTA. [25] Best results were obtained by irrigation of post space utilizing this protocol. [26]

Regarding post cementation, self-adhesive resin cement was selected as these products are less prone to hydrolytic degradation compared to etch-and-rinse and self-etch adhesive systems. Additionally, use of this technique is advantageous due to its simplicity. [27]

There are many techniques to measure the material's bond strength including tensile, pull-out and push-out tests. The later simulates the clinical situation more closely in addition it showed more uniform stress distribution and less cohesive failures. [28,29]

Our results revealed that irrespective of radicular region, **Gr_1** (resin-based sealer) showed statistically significant higher mean value compared to **Gr_2** (bioceramic based sealer) as indicated by two-way ANOVA test. This may be attributed to the fact that epoxy resin does not interfere with polymerization of composite resin. Also, remnants of resin sealer on the walls of root dentin of the post space can improve bonding to resin cement. [30] Cecchin et al. [13] and Alsubait [31] indicated that affinity of this sealer to this cement may be a factor in the high bonding strength of resin sealer to resin cement and that they share a nearly similar chemical composition. This agreed with Vilas-Boass et al [24] who emphasized the superiority of the resin sealer and the fact that there is no interference with the bonding strength of the fiber post when adhesive resin cement is utilized.

Lower values regarding bioceramic sealer group could be attributed to the formation of the hydroxyapatite and tag-like structures, which makes them more difficult in removal during post-space preparation. [24,32] Moreover, the bioceramic sealer remnants in the dentinal tubules' entrance would result in a change in permeability, reactivity and wettability, of the dentine which affects the bond strength. [24,25] This was confirmed by our SEM evaluation which showed less amount of opened dentinal tubules in bioceramic sealer group when compared to resin sealer group. This agreed with Oltra et al [33] who showed that the bioceramic sealer remained more inside the dentinal tubules compared to the resin sealer.

The findings in our research disagreed with Yuanli et al, [8] and Nesello et al, [25] they recorded insignificant difference between the resin and bioceramic based sealers when bonding fiber posts with self-adhesive resin cements. This difference may stem from the design of the study, types of sealers and the sample size.

Regardless to experimental groups, **apical region** group showed statistically significant highest mean value followed by **middle region** group while **cervical region** group recorded statistically significant lowest mean value as indicated by two-way ANOVA test. Pair-wise Tukey's post-hoc test revealed insignificant difference between middle and apical regions. The cervical region showing lower values can be explained by more infiltration of sealers in the wider dentinal tubules present cervically which makes the complete elimination of the sealers more difficult cervically. [30] It may be also related to the higher thickness of cement around fiber posts cervically which might negatively influenced the bond strength due to increase in polymerization shrinkage stresses and the voids within the cement line.

On the contrary, the higher push-out bond strength reported in apical and middle regions might be due to less penetration and better removal of the sealers from the root dentin. [30] This was confirmed by the SEM photomicrographs which showed greater amount of opened dentinal tubules as we go apically.

It should be stressed that the in vitro nature of this present study does not represent the real in vivo environment, but the results of our study can act as a guide for the selection of the suitable type of sealer in the clinical practice.

Accordingly, the null hypothesis that the type of endodontic sealer used would not have any influence on push out bond strength between root dentine and fiber post was rejected.

CONCLUSIONS

Within the constraints of this research, it was concluded that:

1- Bioceramic sealers reduced the bond-strength between root dentin and fiber posts when self-adhesive luting agent was utilized.

2- Bioceramic sealers are more difficult to be completely removed during post space preparation when compared to resin-based sealer.

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