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Effect of Different Surface Treatments on Cone Beam Computed Tomography Image and Push Out Bond Strength of Conventional and Reinforced Fiber Posts.

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ABSTRACT

Statement of problem: Surface treatment of reinforced fiber posts may not always increase adhesion, especially on post/resin based luting agent interface which is weaker than the dentin/adhesive interface. Relatively little information is available on cone beam computed tomography as non-destructive method suitable for investigating the details of the tooth structure and restoration relationship. **Purpose:** The purpose of this study was performed to evaluate porosities and gaps at post/ root dentin interface by CBCT and correlate them to push out bond strength of conventional and reinforced glass fiber posts after different surface treatments; hydrofluoric acid, hydrogen peroxide and sandblasting. **Materials and Methods:** Forty human maxillary central incisors were selected, decoronated to set the remaining tooth length to standardized length of 13mm from the root apex and endodontically treated. The prepared roots were randomly divided into 2 fiber post groups(20 per each). Group 1: white posts DC were selected. Group 2: easy-posts™ were selected. Within each group, posts were further subdivided into 4 subgroups (5 per each) according to surface treatments of the posts. Subgroup A: no treatment, the posts acting as control group. Subgroup B: etching by 9% buffered hydrofluoric acid for 1 minute and bonding. Subgroup C: immersion in 20% H_2O_2 for 15 minutes and double application of silane for 1 minute per each application. Subgroup D: sandblasting by alumina particles and silainization for 1 minute. Posts were cemented inside roots using Duo-link Universal™ resin cement. Samples were examined by CBCT scans to evaluate voids and porosities. The CBCT scans of intra canal posts were measured in the axial plane. All measurements were made at cervical and middle slices in the buccal, lingual, mesial & distal directions. Each specimen was transversely sectioned perpendicular to the long axis of the root to obtain a section 2 mm ± 0.1 in thickness from the root thirds as measured using a digital caliper. Each section was coded and photographed from apical and coronal surfaces using a stereomicroscope.. Three-way analysis of variance ANOVA test of significance was done comparing variables (post, surface treatment and radicular region) affecting mean values. One way ANOVA followed by Tukey's post-hoc test was performed

KEYWORDS

Fiber post-Cone beam computed tomography-Push out bond strength-Resin cement.

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to detect significance between subgroups. Student t-test was done to detect significance between both main post groups. **RESULTS:** It was found that group II post recorded higher adaptability and bond strength mean value(0.32875± 0.0375) (8.352047±1.969) than group I post (0.259688±0.0369) (5.574927±1.959). There were significant differences between the mean adaptability and push bond strength values of different surface treatments and non- significant values among root canal regions. Sandblasting before silanization increased the bond strength of resin cement to the fiber posts. **Conclusion:** porosities and gaps at post/ root dentin interface by CBCT and correlate them to push out bond strength of conventional and reinforced glass fiber posts after different surface treatments were confirmed..

INTRODUCTION

Posts and cores are commonly used in endodontically treated teeth suffering from excessive loss of coronal tooth structure. The selection of an appropriate restoration for endodontic ally treated teeth is guided by both strength and aesthetics. Available prefabricated posts were traditionally made of metal alloys, and their use were reported to have less retention, cause serious types of root fractures,[1] compromise esthetic, and have the risk of corrosion or allergic reactions.[2] The demand for aesthetic posts and cores has led to the development of fiber-reinforced composite (FRC) posts, as an alternative to cast posts and cores and metal dowels in the early 1990s.[3,4]

The popularity of FRC posts can be chiefly ascribed to an elastic modulus that is closer to that of dentin. [1] Other advantages of FRC posts include enabling cementation procedures to be carried out without friction with root canal walls,[1,3,4] reduced risk of vertical root fractures[4,5,6] and distribution of occlusal stresses more evenly in the root dentin, thereby resulting in fewer root fractures. [7-9] With regard to the fiber posts that are currently available on the market, quartz, glass or zircon enriched silicon fibers are pre-stressed and immersed (as fillers) in resin matrix which subsequently is injected under pressure to fill the spaces between the fibers, giving them solid cohesion.[10,11]

The achievement of an effective adhesion to the dentine tissue is a real challenge task mainly due to the degree of hydration of root canal dentin, surface conditioning agent and luting cement used, cavity configuration factor, the use of eugenol-containing sealers, and the anatomic differences in density and orientation of the dentinal tubules at different levels of the root canal area.[12-14]

Various luting agents and corresponding adhesive systems have been proposed for bonding FRC posts to root canal dentin. These materials can be divided into etch-and-rinse adhesives and self-etching systems.[15] Recently, self-adhesive resin cements, which does not require any pre-treatment of dentin, was introduced. Self-etching adhesive approach requires a reduced number of clinical procedural steps and reduced technique sensitivity through eliminating the phosphoric acid and rinsing off procedures.[12]

The use of a 'self-etching primer', a mixture of non-rinsing acidic polymerizable monomers, to simultaneously condition and prime the dentine.[16] This is usually followed by the application of an adhesive resin, the so-called 'two step self-etch adhesive'. Recently, single-step self-etch adhesives combine the primer and adhesive into one bottle enabling simultaneous demineralization and monomer penetration into the dentine.[8]

The possibility of endodontic post failure, which may result in loss of retention; the risk of root canal reinfection due to bacterial micro leakage may be due to: stress concentration; and the difference in modulus of elasticity between post and dentin or bond failure of adhesive systems.[17,18]

Many investigations have been conducted concerning improvement of the bond strengths between the post and the root canal dentin, including different pretreatment techniques of the post surface.[19-22] Chemical pretreatment of FRC posts includes silanization[23,24] and etching with hydrofluoric[25] or phosphoric acid.[26] Mechanical pretreatment (e.g., sandblasting with alumina particles) results in roughening of the post surface and an increased surface area for bonding. Vano and Colleagues confirmed the improvement in post-to-composite bond strength after conditioning methacrylate-based fiber posts by hydrofluoric acid. [22]

Yenisey and kulunk [27] studied the effect of chemical surface treatments on the shear bond strength of quartz and glass fiber posts to a composite resin. They used silane, hydrogen peroxide and methylene chloride to condition the post surface. It was showed that there were significant differences between the shear bond strength for quartz and glass fiber posts. For all groups, the application of hydrogen peroxide for 20 minutes showed the highest bond strength values.

Cone beam computed tomography (CBCT) has recently introduced three-dimensional (3D) imaging into dentistry[28,29] as a nondestructive and non-invasive diagnostic imaging tool[28-31]that can evaluate porosities and gaps at tooth restoration interface. Volume loss during the polymerization and cementation process generates stress that has been recognized as an important factor, leading to failure and the formation of porosities or gaps.[32-34]

Malkoc et al [35] evaluated the porosity volume and localization in luting cements under fixed dental prostheses after cementation. they used: eight resin-based cements (Variolink II, Rely X ARC, Clearfil Esthetic, Bis Cem, Rely X U100, Panavia EX, Super Bond C&B, and Multilink Auto-mix), one resin-modified glass ionomer (Ketac Cem Plus), one glass ionomer (Ketac Cem), and one poly carboxylate (Durelon). The study showed that the liquid and powder forms prepared by manually mixing the cements were found to cause greater porosity.

On bond strength measurement, a variety of test methods are currently available. Amongst which is the push-out bond strength test, which was first used in 1996 to evaluate bonding to root canal dentin.[36] It is believed that the push-out test method provides a better estimation of the actual bonding effectiveness than a conventional shear bond strength test. This is because by using a push-out protocol, failure occurs parallel to the post-cement-dentin interface, which resembles the clinical condition.[36-38] In addition, the push-out test has been considered to be more dependable than the micro tensile test for bonded posts because of the high number of premature failures occurring during specimen preparation and the large data distribution associated with micro tensile testing.[39]

The aim of the present study was to evaluate porosities and gaps at post/ root dentin interface by CBCT and correlate them to push out bond strength of conventional and reinforced glass fiber posts after different surface treatments; hydrofluoric acid, hydrogen peroxide and sandblasting. The tested null hypothesis was that:

1. There are differences in the volumes with regard to porosity and bond strength among the different surface treatments.
2. There are differences in results of CBCT and that of push out bond strength.

MATERIALS AND METHODS

Tooth preparation

40 maxillary central incisors extracted for different reasons, were collected and divided into 2 groups(n=20)per each. Preoperative radiographs of each tooth were obtained to confirm the absence of calcified root canals and internal or external resorption, and the presence of a fully formed apex. Teeth were immersed in 5% sodium hypochlorite for 30 minutes to remove external organic tissues. The crowns were removed to set the remaining tooth length to standardized length of 13mm from the root apex.

Endodontic procedures

The cervical third of each root canal was enlarged with ISO size 50 to size 90 Gates-Glidden drills (Dentsply/Maillefer, Ballaigues, Switzerland). The apical region was prepared up to an ISO size

50 K-file (Dentsply/Maillefer, Ballaigues, Switzerland) 1mm short of the apical foramen. During instrumentation, the root canals were irrigated 3ml of 1% Naocl at each change of file. Subsequently, the root canals were dried with absorbent paper points and obturated with gutta-percha (Dentsply/Maillefer, Ballaigues, Switzerland)by cold lateral compaction using a resin sealer (AH-26; Detrey, Zurich, Switzerland). The coronal and apical openings of gutta-percha filled root canals were closed with flowable resin composite (Tetric N-Flow, IvoclarVivadent, Schaan, Liechtenstein), and then stored in 100% humidity at 37° for at least 72hours to allow for the resin sealer to set according to manufacturer's instructions.

Post space preparation

The filled roots were embedded vertically by parallelometer (PAN model 5261 Artiglio, Italy), in the centers of self-cured acrylic resin blocks, 10mm in diameter and 15mm height (acrostone, Industrial area As-Salam City, Egypt). The gutta- percha filling was removed using Gates-Glidden drills size 2 to size 3 (Dentsply/Maillefer) to achieve post length of 8mm, leaving at least 4mm of filling material in the apical third. Post holes were prepared using the appropriate drill sizes provided in the kit from the respective post manufacturers.

Post surface treatment

The prepared roots were randomly divided into 2 fiber post groups(20 per each). Group 1: white posts DC (FGM, Joinville, Santa catarina, Brasil) were selected with composition of 80% glass fibers and 20% epoxy resin. Group 2: easy-posts™ (Dentsply, Maillefer, United Kingdom) were selected, they composed of combination of an epoxy resin matrix reinforced with zircon enriched silicon fibers. Within each group, posts were further subdivided into 4 subgroups (5 per each) according to surface treatments of the posts. Subgroup A: no treatment, the posts acting as control group. Subgroup B: etching by 9% buffered hydrofluoric acid(HF) (Porcelain etch, Ultradent, Inc. Schaumburg, IL60193, USA) for 1 minute and bonding (All-bond Universal™, Bisco, Inc. Schaumburg, IL60193, USA). Subgroup C: immersion in 20% H_2O_2 for 15 minutes and double application of silane (Porcelain primer Bisco, Inc. Schaumburg, IL60193, USA) for 1 minute per each application. Subgroup D: sandblasting by alumina particles(SB)(150μm size, 3 bar pressure for 2 seconds at 5cm distance) and silanization (Porcelain primer Bisco, Inc. Schaumburg, IL60193, USA) for 1 minute.

Luting procedures

Application of all-bond universal™ (Bisco, Inc. Schaumburg, IL60193, USA) to root canal by micro brush, rubbing for 15 seconds, gently air dried to thin film and excess was removed with paper points then light cured for 10 seconds. Duo-link Universal™ resin cement (Bisco, Inc. Schaumburg, IL60193, USA) was applied onto the surface of the post and into the root canal, scrubbed using a micro brush. Post was then seated into the root canal under pressure of load applicator device which was machined from stainless-steal with 5kg weight for 1 minute. Excess cement was subsequently removed and the resin cement was light cured through the posts.

Cone beam computed tomography measurements

CBCT scans were acquired to evaluate voids and porosities. All teeth were set in a wax sheet positioned over a horizontal phantom plate. The plate was set parallel to the floor and the sagittal plane perpendicular to the horizontal plane. CBCT images were acquired with a first generation CAT Cone Beam 3D imaging system (Imaging Sciences International, Hatfield, PA ,USA). The volumes were reconstructed 0.125 voxels size. The tube voltage was 120 KVP and the tube current was 37.07 mA. Exposure time was 26.9 seconds . The image detector was a flat panel measuring 20x25 cm, image acquired at 14 bit in a single 360 rotation. The CBCT scans of intra canal posts were measured in the axial plane. All measurements were made at cervical and middle slices in the buccal, lingual, mesial & distal directions.

Push-out test procedure

Each specimen was transversely sectioned perpendicular to the long axis of the root using a water-cooled precision saw to obtain a section 2 mm ± 0.1 in thickness from the root thirds as measured using a digital caliper (Pachymeter, Electronic Digital Instruments, China). Each section was 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 filling was then measured, and the radius was calculated

Each root slice was mounted in custom made loading fixture (metallic block with circular cavity at the middle, this cavity for specimen housing having a central whole to facilitate displacement of extruded filling material), then subjected to compressive loading at a crosshead speed of 0.5 mm/min via a computer controlled materials testing machine (Model 3345; Instron Industrial Products, Norwood, MA, USA).

Load applied by 3 plungers of (1, 0.75 and 0.5 mm diameter) corresponding to the radicular third (Coronal, middle and apical) to be tested. The plunger tip was sized and positioned to touch only the filling, without stressing the surrounding dentin, in apical coronal direction to push the filling toward the larger diameter, thus avoiding any limitation to the filling movement possibly owing to the canal taper. This way, it was guaranteed that the overlaying dentin was sufficiently supported during the loading process.

The maximum failure load was recorded in Newton(N) and converted into MPa. The bond strength was calculated from the recorded peak load divided by the computed surface area as calculated by the following formula [40]: Bond = F/A

[F = recorded peak load (N), A (interfacial area) = (π h (r1+r2)]

where, π is the constant 3.14, r^1apical radius,r^2 coronal one, and (h) is the thickness of the sample in millimeters].

Failure manifested by extrusion of filling piece and confirmed by sudden drop along load-deflection curve recorded by Nexygen computer software. The push-out bond strength was determined for each root slice.

Values were recorded, tabulated for each group and statistically analyzed.

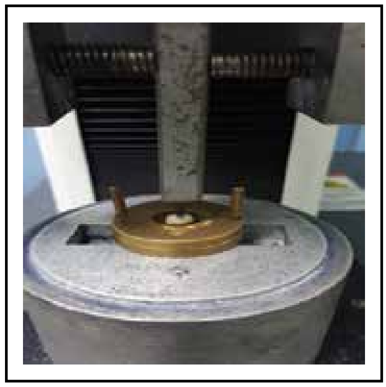

Fig. (1) Sample during push out test

Statistical analysis

Data analysis was performed in several steps. Initially, descriptive statistics for each group results. Three-way analysis of variance ANOVA test of significance was done comparing variables (post, surface treatment and radicular region) affecting mean values. One way ANOVA followed by Tukey's post-hoc test was performed to detect significance between subgroups. Student t-test was done to detect significance between both main post groups. 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.

RESULTS

1-CBCT and adaptability

Adaptability results (Mean ±SD) through voids assessment measured in (mm) for both fiber posts as function of surface treatment and radicular region were presented in table (1) and graphically drawn in figure (2)

Table (1) *Voids mean value (Mean±SD) for both fiber posts as function of surface treatment and radicular region*

Variables	*Gr I (Conventional gl-FRC)*		*Gr II (Zr-reinforced gl-FRC)*	
	Cervical	Middle	Cervical	Middle
Subgroup (A) –Control	0.31375±0.06	0.18875±0.02	0.26625±0.09	0.3025±0.05
Subgroup (B) – HF	0.26875±0.01	0.26625±0.03	0.2675±0.03	0.33±0.03
Subgroup (C) - H_2O_2	0.20375±0.07	0.33±0.05	0.33±0.07	0.39375±0.07
Subgroup (D) – SB	0.2675±0.03	0.23875±0.05	0.19375±0.01	0.14625±0.04

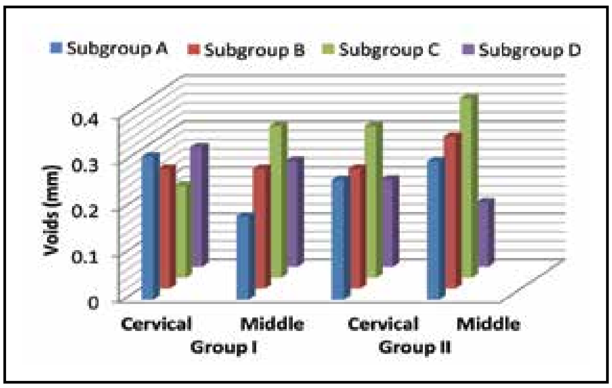

Fig. (2) Histogram of the voids mean values for both fiber posts as function of surface treatment and radicular region.

Total effect of post type on adaptability

Regardless to surface treatment or radicular region, totally it was found that group II post recorded higher adaptability means value(0.32875± 0.0375) than group I post(0.259688±0.0369). The difference was statistically significant as indicated by three way ANOVA test (p=0.05>0.0184).

Total effect of radicular region on adaptability

Regardless to post type or surface treatment, totally it was found that middle region group recorded higher adaptability means value (0.299531±0.0512) than region cervical region group (0.288906 ±0.0426). The difference was statistically non-significant as indicated by three way ANOVA test (p=0.7129 >0.05).

Total effect of surface treatment on adaptability

Irrespective of post type or radicular region, totally it was found that subgroup D recorded highest adaptability means value followed by **sub**group B then subgroup C meanwhile the lowest bond strength means value recorded with subgroup A. The difference was statistically non-significant as indicated by three way ANOVA test (p=0.48213>0.05).

Table (2) *Comparison of total void results (Mean±SD) as function of surface treatment*

Variable		Mean±SD	Rank	Statistics
Surface treatment	Subgroup (A) –Control	0.467813±0.040	A	P value
	Subgroup (B) – HF	0.283125±0.023	A	0.48213 ns
	Subgroup (C) - H_2O_2	0.314375±0.055	A	
	Subgroup (D) – SB	0.111563±0.058	A	

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

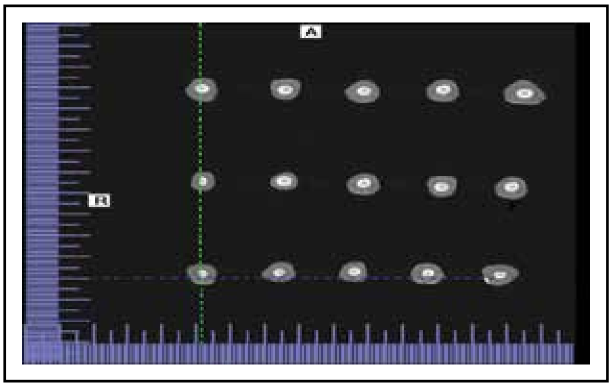

Fig. (3) CBCT images of root canal filling with both conventional and zirconia enriched glass fiber posts at cervical and middle cross sections in axial plane

Interaction between variables

Gr I (Conventional glass-FRC) vs. Gr II (Zirconia-reinforced glass-FRC)

Subgroup (A) – Control

In cervical region; it was found that group I post recorded statistically non-significant higher bond strength means value than group II post as indicated by student t-test (p=0.6528>0.05).While in middle region; it was found that group II post recorded statistically non-significant higher bond strength means value than group I post as indicated by student t-test (p=0.07>0.05).

Subgroup (B) - HF

In cervical region; it was found that group I post recorded statistically non-significant higher bond strength means value than group II post as indicated by student t-test (p=0.9677>0.05).While in middle region; it was found that group II post recorded statistically non-significant higher bond strength means value than group I post as indicated by student t-test (p=0.171>0.05).

Subgroup (C) - H_2O_2

In cervical region; it was found that group I post recorded statistically non-significant higher bond strength means value than group II post as indicated by student t-test (p=0.2303>0.05).In middle region; it was found that group II post recorded statistically non-significant higher bond strength means value than group I post as indicated by student t-test (p=0.4548>0.05).

Subgroup (D) - SB

In cervical region; it was found that group II post recorded statistically significant higher bond strength means value than group I post as indicated by student t-test (p=0.012<0.05).While in middle region; it was found that group I post recorded statistically non-significant higher bond strength means value than group II post as indicated by student t-test (p=0.1297>0.05).

2- Push out bond strength test

Push out bond strength results (Mean±SD) measured in (Mpa) for both fiber posts as function of surface treatment and radicular region were presented in table (3) and graphically drawn in figure (4)

Table (3) *Push out bond strength results (Mean±SD) for both fiber posts as function of surface treatment and radicular region*

Variables	Gr I (Conventional glass-FRC)			Gr II (Zirconia-reinforced glass-FRC)		
	Cervical	Middle	Apical	Cervical	Middle	Apical
Subgroup(A)Control	5.16±0.76	1.379±0.26	5.253±0.98	4.376±0.24	7.44±1.43	7.620±0.59
Subgroup (B) - HF	3.566±0.69	3.224±0.65	6.417±1.36	10.230±1.87	5.912±1.02	12.866±1.62
Subgroup(C) - H_2O_2	7.569±1.88	6.470±1.02	3.134±0.56	4.612±1.07	8.705±2.11	10.658±2.18
Subgroup (D) - SB	5.555±1.18	11.078±1.47	8.096±0.92	8.385±0.58	9.499±2.75	9.936±2.21

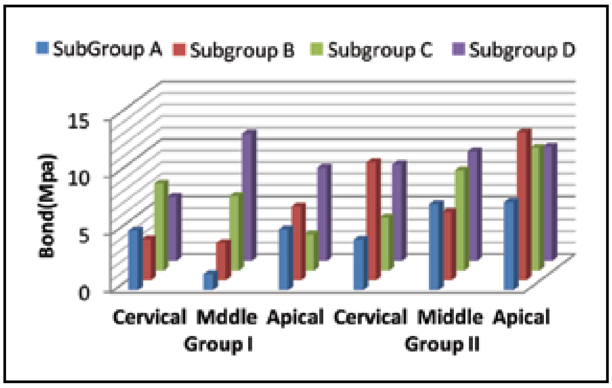

Fig. (4) Histogram of the push out bond strength mean values for both fiber posts as function of surface treatment and radicular region

Total effect of post type on push out bond strength

Regardless to surface treatment or radicular region, totally it was found that group II post recorded higher bond strength means value (8.352047±1.969) than group I post (5.574927±1.959). The difference was statistically significant as indicated by three way ANOVA test ($p=0.008<0.05$)

Total effect of surface treatment on push out bond strength

Irrespective of post type or radicular region, totally it was found that subgroup D recorded highest bond strength means value followed by subgroup B then subgroup C meanwhile the lowest bond strength means value recorded with subgroup A. The difference was statistically significant as indicated by three way ANOVA test ($p=0.002<0.05$). Pair-wise Tukey's post-hoc test showed non-significant ($p>0.05$) difference between (subgroups B and C)

Table (4) *Comparison of total push out bond strength results (Mean±SD) as function of surface treatment*

Variable		Mean±SD	Rank	Statistics
Surface treatment	Subgroup (A) -Control	5.201425±0.958	C	P value
	Subgroup (B) - HF	7.035968±1.731	B	0.002*
	Subgroup (C) - H_2O_2	6.858195±1.114	B	
	Subgroup (D) - SB	8.758361±0.849	A	

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

Total effect of radicular region on push out bond strength

Regardless to post type or surface treatment, totally it was found that apical region group recorded highest bond strength means value(7.997±2.391) then middle region group mean(6.712±2.465) while the lowest bond strength means value recorded at cervical region group(6.181±1.910). The difference was statistically non-significant as indicated by three way ANOVA test ($p=0.3223>0.05$)

Interaction between variables

Gr I (Conventional glass-FRC) vs. Gr II (Zirconia-reinforced glass-FRC)

Subgroup (A) – Control

In cervical region; it was found that group I post recorded statistically non-significant higher bond strength means value than group II post as indicated by student t-test ($p=0.3247>0.05$).

Middle region; it was found that group II post recorded statistically significant higher bond strength means value than group I post as indicated by student t-test ($p=0.004<0.05$).

Apical region; it was found that group II post recorded statistically significant higher bond strength means value than group I post as indicated by student t-test ($p=0.0379<0.05$).

Subgroup (B) - HF

In cervical region; it was found that group II post recorded statistically significant higher bond strength means value than group I post as indicated by student t-test ($p=0.009<0.05$).

In middle region; it was found that group II post recorded statistically significant higher bond strength means value than group I post as indicated by student t-test ($p=0.031<0.05$).

In apical region; it was found that group II post recorded statistically significant higher bond strength means value than group I post as indicated by student t-test ($p=0.012<0.05$).

Subgroup (C) - H_2O_2

In cervical region; it was found that group I post recorded statistically non-significant higher bond strength means value than group II post as indicated by student t-test ($p=0.0947>0.05$).

In middle region; it was found that group II post recorded statistically non-significant higher bond strength means value than group I post as indicated by student t-test ($p=0.1666>0.05$).

In apical region; it was found that group II post recorded statistically significant higher bond strength means value than group I post as indicated by student t-test ($p=0.009<0.05$).

Subgroup (D) - SB

In cervical region; it was found that group II post recorded statistically significant higher bond strength means value than group I post as indicated by student t-test ($p=0.0342<0.05$).

In middle region; it was found that group I post recorded statistically non-significant higher bond strength means value than group II post as indicated by student t-test ($p=0.2949>0.05$).

In apical region; it was found that group II post recorded statistically non-significant higher bond strength means value than group I post as indicated by student t-test ($p=0.2121>0.05$).

Gr I (Conventional glass-FRC) vs. surface treatment

In cervical region; it was found that subgroup C recorded highest bond strength means value followed by subgroup D then subgroup A meanwhile the lowest bond strength means value recorded with subgroup B. The difference was statistically non-significant as indicated by one way ANOVA test ($p=0.1425>0.05$).

In middle region; it was found that subgroup D recorded highest bond strength means value followed by subgroup C then subgroup B meanwhile the lowest bond strength means value recorded with subgroup A. The difference was statistically significant as indicated by one way ANOVA test ($p=<0.0001<0.05$).

In apical region; it was found that subgroup D recorded highest bond strength means value followed by subgroup B then subgroup A meanwhile the lowest bond strength means value recorded with subgroup C. The difference was statistically significant as indicated by one way ANOVA test ($p=0.02<0.05$).

Gr II (Zirconia-reinforced glass-FRC) vs. surface treatment

In cervical region; it was found that subgroup B recorded highest bond strength means value followed by subgroup D then subgroup C meanwhile the lowest bond strength means value recorded with subgroup A. The difference was statistically significant as indicated by one way ANOVA test ($p=0.0066<0.05$).

In middle region; it was found that subgroup D recorded highest bond strength means value followed by subgroup C then subgroup A meanwhile the lowest bond strength means value recorded with subgroup B. The difference was statistically non-significant as indicated by one way ANOVA test ($p=0.5908>0.05$).

In apical region; it was found that subgroup B recorded highest bond strength means value followed by subgroup C then subgroup D meanwhile the lowest bond strength means value recorded with subgroup A. The difference was statistically non-significant as indicated by one way ANOVA test ($p=0.2776<0.05$)

DISCUSSION

Prefabricated post systems have become more popular because they can provide satisfactory results while saving chair time and reducing costs.[41] Passive and tapered prefabricated posts have a configuration that is consistent with the tapered root canal and allow for optimal preservation of radicular tooth structure, especially in the apical region.[42-43]

Post de bonding turned out to be the most frequent failure of endodontic ally treated teeth restored with post and core systems,[44] whereas vertical root fractures were the most serious type of failure.[45-46] Adhesively luted posts revealed improved retention compared to conventionally cemented posts, and thus might reduce the incidence of de bonding [47],so in the present study the adhesive resin cement was selected.

In an attempt to maximize resin bonding to fiber posts, several surface treatments have been suggested. These procedures fall into three categories 1) treatments that result in chemical bonding between composite resin and post (hydrofluoric acid and hydrogen peroxide) 2)treatments that intend to roughen the surface(sandblasting and etching)or 3)combining micromechanical and chemical components either by using the two above mentioned methods. Some studies [26-48,49] suggested that mechanical techniques are more effective than chemical techniques. However some of these techniques may compromise the integrity of the fiber post.

The aim of the present study was to evaluate porosities and gaps at post/ root dentin interface by CBCT and correlate them to push out bond strength of conventional and reinforced glass fiber posts after different surface treatments; hydrofluoric acid, hydrogen peroxide and sandblasting. Thus, the null hypothesis of this study was confirmed in differences in the volumes with regard to porosity and bond strength among the different surface treatments while rejected in differences in results of CBCT and that of push out bond strength.

The 3D visualization of a tooth and oral structures using CBCT imaging represents an impressive advance in dentistry. In the past, 3D structures were superimposed on periapical radiographs; today, they may be perfectly assessed using CBCT scans.[29-31,50-2]Periapical radiographs are the standard method to evaluate root canal filling and intra canal post. However, several authors have described their limitations.[50-2] At the same time, high density materials may produce image artifacts, which may limit interpretation, reduce image quality, and induce diagnostic errors conditions.[53]

In many ways, the degree of bonding between the post and dentin determines the overall success of restorations. Traditionally, light or electron microscopy and other specialized methods are used to evaluate the tooth structure/post interface and cement gap; however, most of these methods are destructive and can only be applied after preparing experimental specimens by cutting the tooth into halves or a series of thin sections. For this reason, these methods do not permit the dynamic investigation of peculiarities that develop at the post/dentin interface. In short, a novel approach to the nondestructive evaluation of cement post adhesion is required.[54]

CBCT is a nondestructive method of analysis that allows high resolution of the dental cement, where porosities can be found between the post and root dentin. Therefore, in this study, volume of porosities between post and cement could be evaluated, providing a more realistic representation of the internal structure of luting cement.

Milutinovic-Nikolic et al [55] showed that the majority of pores in many types of cement are below the 0.1to18μm sections by CBCT used in this study which agreed with the present study.

The disadvantage of the CBCT is its low resolution when compared to using an electron or optical microscope. Furthermore, considering that the images result from radiation, there may be artifacts from refraction. Various materials having different values of X-ray absorption hinder the definition of the outlines between these materials.[34] It is very problematic to separate the lines between two materials with the same X-ray absorption coefficients when they are in contact. This condition should be evaluated when using the CBCT technique; however, this study demonstrated that CBCT was very useful for developing a standard method to examine the porosities and where they were located in vitro.

Milutinovic-Nikolic et al[55] compared the open porosity and pore size distributions of different cements under various restorations. It was found that the resin-based cement showed the least porosity. In this study resin cement was selected.

Our findings showed that group II post recorded higher adaptability means value than group I post. The difference was statistically significant. Regardless to post type or surface treatment, it was found that middle region group recorded higher adaptability means value than cervical region group. The difference was statistically non-significant.

Irrespective of post type or radicular region, it was found that sandblasting subgroup recorded highest adaptability means value followed by Hydrofluoric subgroup then Hydrogen peroxide subgroup mean while the lowest bond strength means value recorded with control subgroup A. The difference was statistically non-significant

To conduct the present study, two types of fiber posts were selected. White posts DC with composition of 80% glass fibers and 20% epoxy resin and easy-posts™ which is a combination of an epoxy resin matrix reinforced with zircon enriched silicon fibers.

Despite the satisfactory bond strengths achieved, the mechanical treatments were considered too aggressive for fiber posts, because of the risk of significantly modifying their shape and fit within the root canals.[34] Some researches thus advocated the use of chemical treatments to enhance bonding. Moreover, chemical treatments save chair time and can be done safely in the clinic.

The rationale for conditioning of glass fiber post with chemical agents prior to silanization relies on two purposes, first; removing a surface layer of the resin matrix rendering more silica of glass fibers available for silanization, thus improving the fiber post surface bonding area. Second; the spaces between the fibers also provide sites for micromechanical retention of resin composites.[56]

Fiber posts are comprised of a matrix resin that surrounds different types of fibers. In the glass fiber posts, the fibers are made of glass and the matrix is made of epoxy resin.[7] The epoxy polymers cannot chemically bond with composite resin cements because of their highly crosslinked structure.[25] Therefore, some authors propose using silane coupling agent on the fiber post surface to increase the tensile bond strength(TBS) between the fiber post and resin cement. However, it has been said that silane cannot increase the bond strength of the fiber posts to resin cements or composite core materials.[27,57,58] In fact this is due to this fact that the chemical bond is achieved mainly by creating covalent bonds between the silane coupling agent and the composite resin; and between silane and the exposed glass fibers or filler particles of the post.[59] In the present study, likes some other investigations, it was found that silane after surface treatment could increase the TBS of the fiber posts to resin cements.

Roughening the fiber post surface with micromechanical procedures can bring the glass fibers in better contact with silane coupling agent,[60,61] so sandblasting is used to roughen the fiber posts surface for better bonding.[62,63]This results in accordance with our results.

Sandblasting can damage the glass fibers.[64] Yet, Radovic et al.[65] showed that even if sandblasting can improve the bond strength between fiber post and resin cement but water aging can reduce the bond strength of sandblasted specimens.

The results of the present study showed significant increase in push-out bond strength values after 0.9% Hydrofluoric acid etching followed by hydrogen peroxide and control group. Vano et al [22] proposed hydrofluoric acid for etching glass fiber posts. The acid is able to "activate" the post surface, allowing for the formation of micro retentive spaces.

Hydrofluoric acid etching before silane application also enhanced the bonding between FRC posts and resin cement. However, this technique produced substantial damage to the glass fibers, which may affect the integrity of the post. This is due to the extremely corrosive effect of hydrofluoric acid on the glass phase of a ceramic matrix,[29-36] and thus these procedures cannot be recommended for clinical use due to possible weakening effects on the stability and integrity of the posts.

The same findings were confirmed by Addison and Fleming [58], Vano et al [22] and Mazzitelli et al [62]In these studies; despite the improvement in post-to-composite bond strength when hydrofluoric acid was used to condition fiber posts, remarkable surface alteration, ranging from micro cracks to longitudinal fractures of the fiber layer was detected. As a consequence, it was not possible to suggest general guidelines for using hydrofluoric acid in the surface etching of esthetic fiber posts. easy-posts™ showed statistically significant higher mean push-out bond strength than white post DC.

Hydrogen peroxide (H_2O_2) can selectively dissolve the epoxy matrix without damaging the glass fibers.[6,20,39,40] The present study showed that using H_2O_2 before silanization gave lower push out bond strength in comparison to sandblasting + silane and hydrofluoric acid +silane ($P<0.05$)which is in accordance with some other studies.[62,66,67]

In the studies that bonding agent was applied immediately after using H_2O_2 (without silane coupling agent as a mediator), the TBS mean value was reduced.[69] However, some authors claimed that pretreatments are not necessary before silane application.[70]

The results of this study showed that there was no significant difference in the push out bond strength among root regions. These results are consistent with some previous studies which reported that bond strength to root canal is not affected by the root region in the root canal[70-72].

On the contrary, Mumcu et al [73]found that there is significant effect of root region on push-out bond strength. Irrespective of post type, highest bond strength values were achieved in the cervical region, whereas the lowest values were obtained in the apical region. This outcome was explained on the basis of difficult access to the apical region and a possible limitation of cement flow. At the middle and apical regions, reduction in curing light transmission could account for a decrease in the polymerization of the luting cements, thereby accounting for the lower bond strengths achieved by the luting cements in these regions. As for the vast difference in push-out bond strength between the cervical and apical root regions, it could be attributed to the easy accessibility of the cervical region versus that of the apical region, hence making it easier for a more thorough etching process and application of adhesive agents.

Application of all-bond universal™ to root canal by micro brush, rubbing for 15 seconds, gently air dried to thin film and excess was removed with paper points then light cured for 10 seconds. Duo-link Universal™ resin cement was applied onto the surface of the post and into the root canal, scrubbed using a micro brush,The cement used in the present study is dual cure self-etching cement. It was inserted into the root canal utilizing an elongation tip, resulting in less chance of bubble formation and air-entrapment in the apical region.

On the other hand, some authors as Bitter et al.,[60]Muniz and Mathias [74]obtained the best results in the apical region. Such discrepancies in bond strength results were attributed to differences in the distribution and density of dentinal tubules at different root regions. It has been reported that the density of dentinal tubules in the cervical region was higher than that in the apical region, and that the diameter of tubules decreased in the apical direction.[75]

The present study had some limitations. For example, the specimens had no coronal tooth structure, only one type of adhesive was evaluated and the influences of fatigue loading on the push out tensile bond strength of specimens were not investigated.

CONCLUSION

Within the limitations of this in vitro study, the following conclusions were drawn: porosities and gaps at post/ root dentin interface by CBCT and correlate them to push out bond strength of conventional and reinforced glass fiber posts after different surface treatments were confirmed. There were significant differences between the mean push out bond strength values of different surface treatments and non- significant push out bond strength among root canal regions. Sandblasting before silanization increased the bond strength of resin cement to the fiber posts.

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