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EVALUATION OF THE PUSH OUT BOND STRENGTH OF FIBER POST SYSTEM AND POLYETHERETHERKETONE (PEEK) POST AFTER DIFFERENT SURFACE TREATMENTS. (AN INVITRO STUDY)

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ABSTRACT

Objective: This study aimed to assess the effect of various surface treatments on the push-out bond strength of custom-made PolyEtherEtherketone(PEEK) and prefabricated glass fiber posts after being treated with different surface treatment materials.

Materials and methods: Sixty single rooted upper central incisors that were recently extracted were selected. All root canals were endodontically treated and post spaces prepared then divided into two equal groups based on posts type. Prefabricated glass fiber posts (n=30) were used in the first group(G), while milled PolyEtherEtherketone posts (n=30) were used in the second group(P). Based on surface treatment, each post group was randomly divided into three equal subgroups: subgroup(SB): sandblasting with 50μm Aluminum-oxide particles, subgroup(SE): etching with 98% Sulfuric acid and subgroup(HE+SC): etching using 9.5% hydrofluoric acid followed by silane coating. All post surfaces were examined using a scanning electron microscope (SEM). All posts were bonded with self-adhesive resin cement according to manufacturer instructions. All samples were sectioned into; coronal, middle and apical sections with a thickness of 2 mm each. Then, push-out test was carried out on the samples using a universal testing machine. Finally, the data were statistically analyzed.

Results: There was a statistically significant difference (P=0.002) with the mean push-out value higher in glass fiber than PEEK post (4.18±1.72MPa vs. 2.65±2.12MPa, respectively).

Conclusion: The glass fiber post's bond strength was higher than that of the PEEK posts. PEEK posts that were sandblasted with aluminum-oxide particles showed a noticeable improvement in bonding and would be a good choice for PEEK post surface treatment.

KEY WORDS: Hydrofluoric, sulfuric, sandblasting, CAD-CAM.

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INTRODUCTION

Posts and cores are used in endodontically treated teeth with greater coronal damage to restore their form and function. An endodontic post is mostly used to increase the retention of the coronal restoration in an endodontically treated tooth that has significantly lost coronal structure as a result of caries, severe wear, or previous restoration. [(1)]

The design and material of the post play an important role in success of the post system used in endodontically treated teeth and affect their durability. Posts have been constructed from a variety of materials, including wood from the 18th century, metal alloys, and more recently, fibers such as: carbon, glass and polyethylene fibers, ceramics, zirconia, and polyetheretherketone (PEEK). [(2)]

When compared to metal posts, prefabricated glass fiber posts are regarded to be better choices for endodontically treated teeth because of their adequate aesthetics, consistent stress distribution, biocompatibility, resistance to corrosion, ease of handling, and adhesion to restorative resinous materials. [(3)]

PolyEtherEtherKetone (PEEK) is gaining popularity in the dental field because of its exceptional fatigue resistance, low water sorption, superior mechanical, thermal, and chemical properties, and excellent biocompatibility. [(4)]

One important benefit that allows PEEK to act as a stress breaker and lessen stresses transferred to the restorations is its elastic modulus, which matches dentin. Dental materials with dentin-like elastic moduli disperse stresses evenly. Moreover, its radiolucency makes it feasible to assess the treatment methods step-by-step. In a variety of dental applications, including fixed and removable prostheses, dental implants, their abutments and orthodontic wires, PEEK is regarded as metal-free, and aesthetically pleasing material due to its whitish tint. Because of its great fracture resistance and capacity to absorb shock, this material has replaced metal, glass, and ceramics. [(4)]

Various surface treatment modalities have been evaluated to attain sufficient bond strength of Fiber and PolyEtherEtherKetone posts to resin-based materials, These include hydrogen peroxide, hydroflouric acid, sulfuric acid, tribochemical silica, sandblasting, and plasma treatment.

The push-out test appears to be more precise and dependable method in determining the posts' bond strengths to root dentin than other methods since it avoids stresses superimposition during specimen cutting. [(5)]

Therefore, this study purpose was to assess the push-out bond strength of prefabricated glass fiber posts and milled PolyEtherEtherketone (PEEK) posts treated with different surface treatments; sandblasting, etching with sulfuric acid and etching using hydrofluoric acid followed by silane coating. The null hypothesis was that there is no difference in the push out bond strength between glass fiber post system and PolyEtherEtherKetone (PEEK) post after different surface treatments.

MATERIALS AND METHODS

The study was approved by the research ethics committee of the Faculty of Dentistry, Minia university (RHDIRB2017122004) with protocol number (629/2022) at meeting number(89)

Sample Grouping

A windows software named G-power 3.1.9.4 (Heinrich-Heire, Dusseldorf, Germany) was used to determine the sample size for posts, ANOVA F test was used: fixed effect, omnibus and one way. Based on previous studies [(1, 6)], A beta error ß of up to 20% was acceptable with an 80% study power and an alpha level α set at 5% with a 95% significance level. the predicted sample size (n) would be 60 samples total with 10 samples for each group.

Sixty maxillary central incisors with single and complete roots were extracted and collected from the Oral Surgery department, Faculty of Dentistry, Minia University, due to periodontal and orthodontic reasons. To ensure that there was no caries and that the root canal architecture was normal, visual and radiographic examinations were conducted. Teeth were selected based on inclusion criteria. The following are the inclusion criteria: teeth with average length of 21 ±1 mm, straight-rooted teeth, uniformly sized and shaped teeth, and intact clinical crowns. These are the exclusion criteria: Teeth having immature open apices, cracks, root resorption (internal or external) carious or fractured roots, and endodontically treated teeth. These teeth were kept at room temperature in a container with 0.9% saline solution.

To standardize the root lengths in the samples to 14 ± 1 mm, decoronization was carried out 1 mm above the coronal cemento-enamel junction using a low speed disc installed on a dental lathe motor (Knuth, Germany) under continuous irrigation.

Endodontic Treatment

After pulp extirpation, a 15 K-file (Mani Inc, Japan) was used to verify the patency of the canals and to acquire a standard working length to be (14± 1 mm). All root canal preparations were carried out manually using the step-back approach with the master file number of 60 (Mani Inc, Japan). During root canal preparation, the canals were irrigated using 2 ml of 5.25% NaOCl after each file used. Then, the canals were obturated using gutta-percha cones (Dentsply , USA) and root canal sealer (META BIOMED ADSEAL Resin sealer ,Korea) by using the lateral condensation technique. Finally, the canal orifices were sealed by eugenol-free temporary filling material. The roots were kept for seven days at 37°C with 100% relative humidity. [7]

Post Space Preparation

The average length of the roots was 15mm after decoronization so Each tooth's post space was prepared to a standard length of 10 mm, with 5 mm of gutta percha left in the apical third to preserve the apical seal. [8] After measuring the length at 10 mm, the gutta percha was removed using a pilot reamer (Nordin, H, Nordin, Swiss). Drills N1 (white coded) and N2 (yellow coded) were next, and drill N3 (red coded) was the last one to be used..

Between each drill, saline solution was used to flush the canal.Following post-space preparation, radiographs were taken on each sample to confirm complete removal of any remaining gutta-percha and sealer.

Based on the type of the post, the samples with prepared post spaces were divided into two groups, with thirty samples each:

- ***Group G: Glass Fiber Post (Prefabricated): (30 samples)***

Once drill N3 was reached, a glass fiber post, size 3 (Nordin Glassix plus, Switzerland) color coded with red which corresponds to the drill N3 was chosen to be used in Group G samples.

- ***Group P: Milled PEEK post (Custom made) :(30 samples)***

Once drill N3 reached the same size and diameter as the prefabricated post, debris were removed by irrigation with saline and the canal was dried using paper points prior to the intracanal scanning for construction of the PEEK posts.

(A) Intra-canal digital Impression for Custom-made PEEK Post:

An intraoral scanner (IOS) (MEDIT i700; Medit, Seoul, Korea) was used to digitally scan the post space . Medit system does not require the use of powder for scanning. During scanning, the intra-oral scanner was used at 45 ° angle with the sample. the scanner was moved to the mesial, lingual, distal, and buccal sides, starting from the middle of the root canal and successive images were obtained as shown in **(Figure 1)**. All data were sent to the laboratory to start designing and then milling of the peek posts. [9]

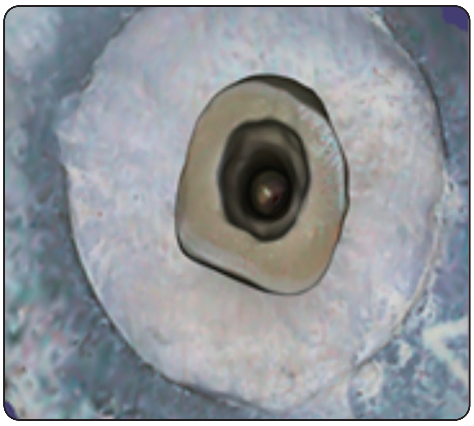

Fig. (1) Post space aquisition with Medit i700.

(B) Construction of PEEK post (custom made):

Using a CAD software program (Exocad dental cad software, exocad GmbH), a virtual cement gap of 80 μm was included in the design of the post's digital 3D form. The acquired data were transferred to the Milling Machine (**Roland DWX-52D 5-Axis Dental Milling Machine**), where thirty PEEK posts were manufactured from a blank (CopraPEEK blank, Germany)(Ø 98 mm, T15mm), as shown in **(Figure 2).**

Fig. (2) Milled PEEK post with 10 mm in length.

Surface Treatment Methods:

Subgroup GSB and PSB (10 samples each) : The posts were Sandblasted using 50 μm Al_2O_3 particles by directing the particles perpendicularly onto all surfaces of the post for 10 seconds at 2.8 bars pressure and a distance of 10 mm . Following sandblasting, the posts were washed with water for 30 seconds to remove any remaining AL2O3 particles from their surface. They were then dried for 20 seconds using oil-free compressed air. [1,4]

Subgroups GSE and PSE (10 samples each): Posts were etched with 98% sulfuric acid for 60 seconds and followed by a 60-second rinse in deionized water and then dried with oil-free compressed air for 20 seconds **.** [3,4]

Subgroup GHE+SC and PHE+SC (10 samples each): The posts were first etched for 90 seconds using 9.5% hydrofluoric acid etching (BISCO porcelain etch , USA), then washed with water to remove the acid. Next, the posts were coated using a disposable brush with silane coupling agent (BISCO porcelain primer , USA), and left to air dry for five minutes. [1,10]

Scanning electron microscope (SEM) evaluation of the treated Posts:

After surface treatment of posts, representative samples were evaluated after surface treatment under scanning electron microscope (SEM) (JEOL JSM-5400 LV, USA) at 200 × magnification after sputter coating with gold.[11]

Cementation of the Posts:

The canal was rinsed with 0.9% saline solution. Secondly, 5.25% NaOCl solution was used to disinfect the root canal. The canal was then flushed using 3ml of 0.9% saline solution. Finally, paper points were used to dry the canal. **TheraCem® (Bisco, USA)** dual-polymerizing self-adhesive auto-mixing syringe was used. The cement was carefully injected using an endo tip that was placed inside the canal. the post was inserted within the canal. LED polymerization light cure unit (ACTEON SATELEC, France) was used to light cure the resin cement at 1,200 mW/cm2 for 40 seconds. and after that, these samples were put at room temperature in 0.9% saline solution for 7 days to guarantee complete resin cement polymerization prior to testing.

Push out test:

After cementation, all samples were kept for a week at 37 ^{0}C in a lightproof box containing sterile saline. Then, each root was mounted to plastic mold (2.5 x 5 cm) which was isolated with separating medium (Acrostone,Egypt) for easily removing and fixed apically then a self-cured acrylic repair material (IMICRYL,SC,self cure,SOGUK,turkey) was poured into the mold to make acrylic block for proper cutting of the roots. Coding acrylic block was done according to type of post and surface treatment that was done [(8)].

Using a diamond disc 0.6 mm thick mounted on an IsoMet 4000 microsaw (Buehler, USA), all roots were sectioned into 3 sections: coronal, middle, and apical sections with a thickness of 2 mm each, as shown in **(Figure 3).** The process was carried out under water cooling at a rate of 10 mm/min and 2500 rpm speed.

Next, push-out test was carried out on the samples using a universal testing machine (Instron universal testing machine model 3345 England). The specimens were loaded using a stainless-steel plunger with a 0.9 mm diameter that was chosen so as not to put any stresses on the surrounding walls of the post space.

The tests were performed with a 500 N load cell at a cross head speed of 0.5 mm/min until the post was extruded [(1,2)]. as shown in **(Figure 4)**. A computer software (Bluehill 3 version3) was used to record the data. The push-out bond strength was determined by taking the highest value found.

The loaded area in (mm^2) was determined: (Area= Circumference of restoration × Thickness).

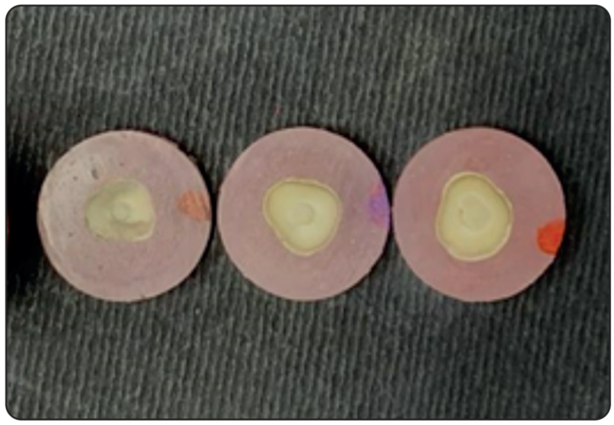

Fig. (3) Three Sections and Color Coding of Each Sample.

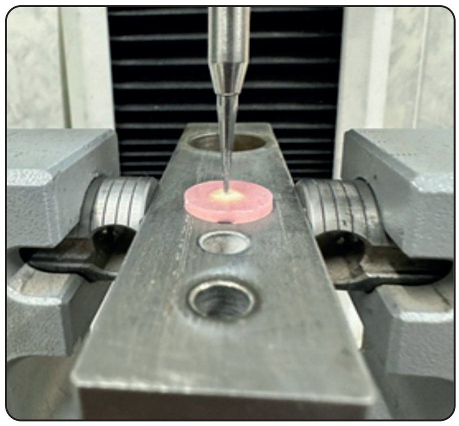

Fig. (4) A Slice Mounted in Universal Testing Machine.

Push-out strength in (MPa) was calculated as: (Force (N) / Area (mm^2)).

The obtained findings from the test were statistically analyzed after being calculated and tabulated.

RESULTS

1. Scanning electron microscope Images of each study group after surface treatment:

SEM analysis of the treated Posts demonstrated that surface modifications varied between the different groups as shown in **(Figure 5).**

- Group (PSB) exhibited a rough surface resulted from sandblasting
- Group (PSE) showed the largest micropores compared with other treated peek posts.
- Group (PHE+SE) exhibited small micropores in the etched surface.

- Group (GSB) showed surface roughness with intact superficial glass fibers.
- Group (GSE) exhibited surface roughness with broken glass fibers and a partially disintegrated matrix.
- Group (GHE+SE) showed a relatively rough etched surface impregnated by silane.

2. Results of push out test

The mean values and standard deviations of the push-out strengths for all groups of posts subjected to different surface treatments were calculated. Mann-Whitney and Kruskal Wallis tests were used to compare between the groups.

A. Push-out Bond Strength of glass fiber and PEEK Posts after different Surface Treatment methods:

As shown in **(Table 1)** and **(Figure 6)**:

1. The mean value was 4.53 MPa for the HE+SC group, 4.00 MPa for the SB group, and 3.31 MPa for the SE group in the glass fibre glassix plus post, indicating a significant difference between the surface treatment groups.
2. The mean value was 4.88 Mpa for the SE group, 2.25 MPa for the SB group, and 0.83 MPa for the HE+SC, indicating a significant difference between the surface treatment groups in the PEEK post.

TABLE (1) Push-out Bond strength of glass fiber and PEEK posts after different surface treatment methods.

	SE	HE+SC	SB	P-value
Fiber:				
Mean ± SD	3.31 ± 0.77	4.53 ± 1.84	4.00 ± 0.93	0.014*
Median (Range)	3.47 (2.20-5.12)	4.25 (2.75-9.50)	4.08 (2.43-5.32)	
Peek:				
Mean ± SD	4.88 ± 1.26	0.83 ± 0.77	2.25 ± 1.71	0.000*
Median (Range)	5.15 (2.04-6.55)	0.38 (0.16-2.41)	2.07 (0.23-5.22)	

Mann-Whitney test * Statistically significant difference ($P < 0.05$)

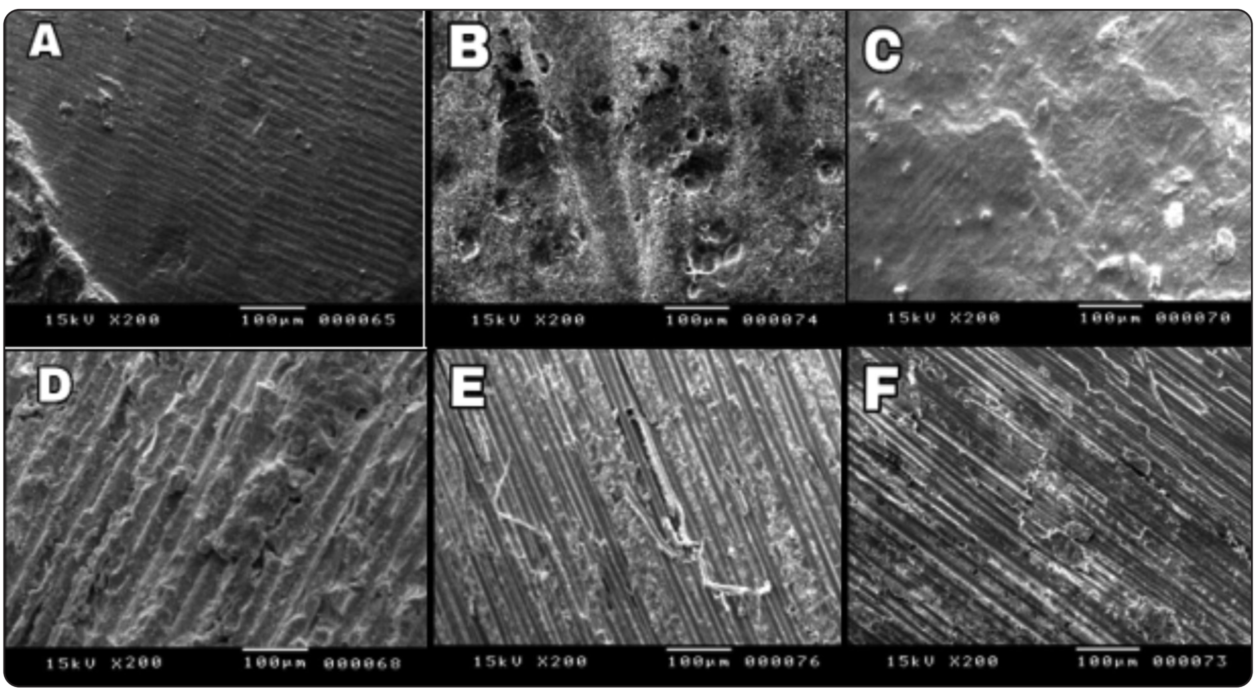

Fig. (5) Representative SEM photomicrographs of the treated surfaces A.Group: PSB B.Group: PSE C.Group: PHE+SE D.Group: GSB E.Group: GSE F.Group: GHE+SE

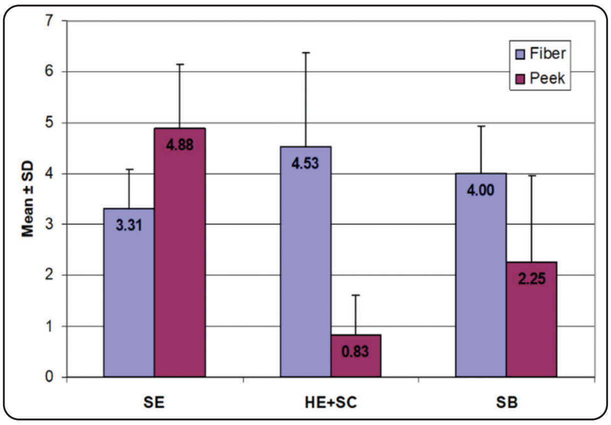

Fig. (6): Histogram presenting push-out bond strength of glass fiber and PEEK posts after different surface treatment methods.

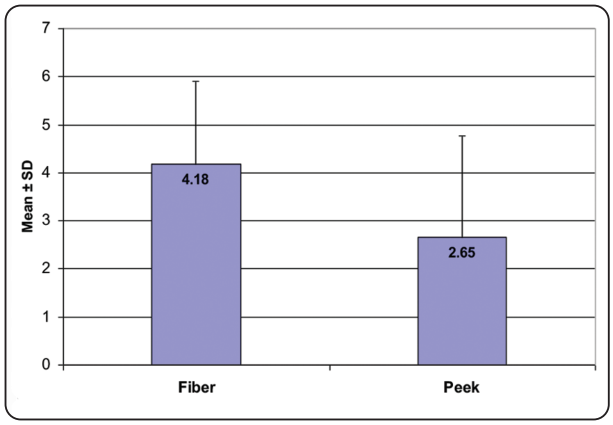

Fig. (7): Histogram presenting Push-out strength in each post type based on sections.

B. Push-out bond strength in each post type based on sections:

As shown in **(Table 2)** and **(Figure 7):**

1- In the coronal and apical parts, there was a significant difference between the Glassix Plus Posts and PEEK Posts, but no difference in the middle section.

2- The values recorded at the coronal sections were highest and at the apical sections were lowest, for both Glassix plus fiber and PEEK posts.

TABLE (2) Push-out strength in each post type based on sections:

	Fiber	Peek	P-value
Coronal:			
Mean ± SD	5.98 ± 1.72	3.97 ± 1.85	0.024*
Median (Range)	5.10 (4.50-9.50)	4.00 (1.23-6.55)	
Middle:			
Mean ± SD	3.73 ±0.63	2.60 ± 2.06	0.141
Median (Range)	3.70 (2.72-4.90)	2.07 (0.34-5.83)	
Apical:			
Mean ± SD	2.83 ± 0.56	1.39 ± 1.70	0.015*
Median (Range)	2.70 (2.20-4.08)	0.33 (0.16-4.90)	

Mann-Whitney test * Statistically significant difference (P < 0.05)

C-Push-out Bond Strength based on post type

The findings presented in **(Table 3)** and **(Figure 8)** showed that there was a statistically significant difference (P =0.002) with the mean push-out value higher in glass fiber than PEEK post (4.18±1.72 MPa vs. 2.65±2.12 MPa, respectively).

TABLE (3) Push-out strength based on post type:

	Fiber	Peek	P-value
Mean ± SD	4.18 ± 1.72	2.65 ± 2.12	0.002*
Median (Range)	3.80 (2.20-9.50)	2.30 (0.16-6.55)	

Mann-Whitney test * Statistically significant difference (P < 0.05)

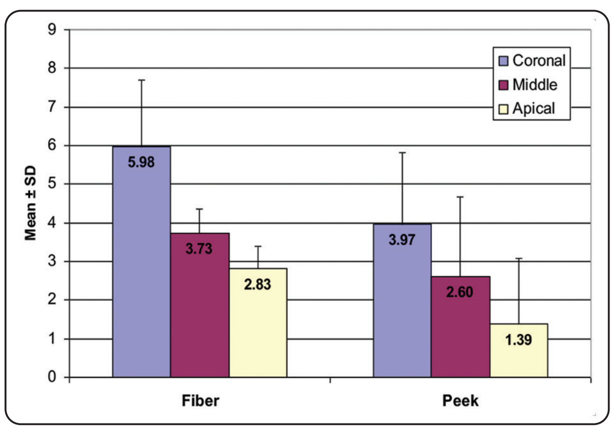

Fig. (8) Histogram showing push-out strength based on post type.

D- Push-out Bond Strength based on surface treatment method

As shown in **(Table 4)** and **(Figure 9)** :

1- Group HE+SC showed the greatest mean push out value, 4.78 MPa, followed by groups SE and SB, whose respective mean values are 3.35 MPa and 2.13 MPa, respectively.

2- There was significant difference between all the groups.

TABLE (4) Push-out strength based on surface treatment method:

	SE	HE+SC	SB	P-value
Mean ± SD	3.35 ± 1.17	4.78 ± 1.86	2.13 ± 1.05	0.000*
Median (Range)	3.50 (2.04-6.55)	4.41 (0.16-9.50)	3.60 (0.23-5.32)	

Mann-Whitney test * Statistically significant difference (P < 0.05)

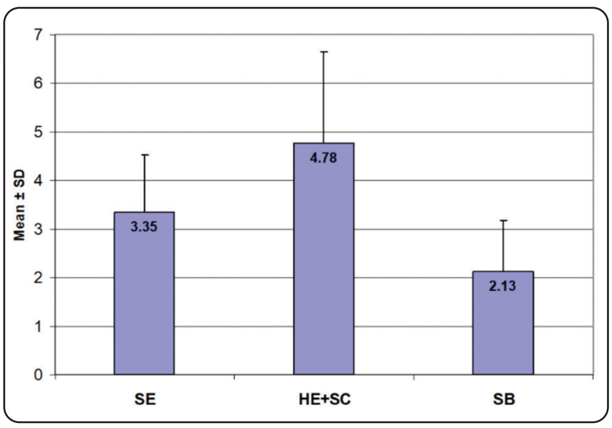

Fig. (9): Histogram presenting Push-out strength based on surface treatment method.

DISCUSSION

Because their elastic moduli matching to dentin and their ability to produce a good stress distribution, Glass fiber posts are being viewed as promising alternatives to cast metal posts. Additional benefits of these posts include mechanical strength, resistance to corrosion, and biocompatibility. Additionally, they improve light transmission within the gingival and root tissues above it, which eliminates or lessens the dark appearance that metal posts and cores and non-vital teeth are frequently associated with. [13].

Alqahtani. (2021) [14] in a systematic review concluded that the PEEK post exhibited encouraging outcomes with excellent mechanical and bonding capabilities. It might work well as a substitute material to be used in clinical practice.

Numerous factors influence the bond strength between a post and a root canal, including the post's material type, surface treatment, and adhesive cement utilised [1]. Glass fiber and peek posts can be luted with several types of cements (i.e. conventional cements, self-adhesive cements). The best option has shown out to be resin-bonded luting, however traditional cementation may also be used. If post/resin cement bonds are associated with micromechanical retentions, they might be stronger and more effective. This is because surfaces that have been roughened may facilitate the entry and flow of resin cement into the micro-retentions, strengthening the micromechanical interlock. [15,16]

The present study aimed to evaluate the effect of sandblasting with aluminium oxide particles, etching with 98% sulfuric acid and etching using 9.5% hydrofluoric acid followed by silanization on the push-out bond strength of both milled custom-made PEEK posts and ready-made glass fiber posts.

The null hypothesis was that there is no difference between the push out bond strength of fiber post system and PolyEtherEtherKetone (PEEK) post after different surface treatments.

In this study, upper central incisors were selected because they are the main teeth in the esthetic zone which are our concern in placement of esthetic posts and appear to be good options to simulate the clinical situation for the root canal treated anterior teeth.

There is currently no clear protocol for the standard storage of teeth in order to facilitate research on their chemical or physical characteristics. Ethanol, Hanks' balanced salt solution, deionized water, saline and distilled water are some examples of potential storage media. Neverthless, there isn't an ideal technique for storing teeth that meets all requirements. Teeth should ideally be kept moist and stored in a solution to simulate the oral conditions because they come into constant contact with saliva [17].

As per the protocol outlined by **Goracci, et al. (2004)** **[18]**, the extracted teeth in this investigation were stored at room temperature in 0.9% saline solution [18,19].

Abramovitz (2004) [8] recommended leaving 3–6 mm of gutta percha after the preparation of post space in order to preserve the apical seal, although the authors of numerous other later researches suggested leaving 4-5 mm of gutta percha in place. It permits an appropriate apical seal. [8] Therefore, 4-5mm of gutta were left in this study.

In our study, Digital impression technique using Medit i700 intraoral scanner was used for obtaining the impression of the post space.

According to **Benli, et al. (2018)** [9], Comparing the digital impression technique with the conventional technique yielded similar findings, suggesting that the digital technique can serve as a viable alternative for collecting post-space impression data. This suggested technique reduced the clinical time for taking the impression. But, this needs experienced clinicians, as it takes time to learn the digital impression technique totally from the beginning. Moreover, digital technique reduces the need for conventional impression materials and any potential drawbacks for the patient's comfort, such as taste, smell, or gag reflex. Therefore, patients with severe reflex injuries or traumatic injuries may find this method helpful. [9].

Dupagne, et al. (2023) **[20]** compared the accuracy of four intraoral scanners in scanning post space and found that Medit i700 gave accurate results.

In this study, push-out test was used to assess the bond strength of both types of posts. The advantage of this test is that it is more clinically applicable. On the other hand, it has been proposed that if the push-out test is carried out on thick root segments or the entire post, a very non-uniform tension may emerge at the adhesive interface. **Goracci, et al. (2004)** [18] examined the ability to precisely evaluate the bond strength of fiber posts luted inside post spaces by comparing between the microtensile approach and the push-out test. The push-out test yielded more precise results. When using the microtensile approach, there were a lot of early failures and a wide variation in the data distribution. [18,21].

The current study's findings showed that glass fiber posts had a greater bond strength to root canal than PEEK posts did. These findings are consistent with previous studies **Arjun. (2019)** [2] and **El Masry, et al. (2023)** [22] **.** The tight bond between the resin cement and the fiber post's resin matrix and PEEK posts' reduced affinity for adhesive resin cements could be the cause of this. Additionally, because methacrylate-based adhesives and resin cements have an affinity for bonding with the methacrylate resin matrix of the post.

Regarding to the influence of various surface treatments on the PEEK post, etching with 98% sulfuric acid(H_2SO_4) gave the highest bond strength values than other PEEK groups treated with other methods. The effect of sulfuric acid was obvious in SEM image of the PEEK group treated with sulfuric acid. The high H_2SO_4 concentration and its notable impact on the sulfonation of the benzene ring of polyetheretherketone molecule may be responsible for the enhanced bond strength.[4,23]. By adding more functional sulfonate groups (-SO3) to the PEEK polymer chains, this enhanced the hydrophilicity of the PEEK surface, which allows it to react with the resin cement's methyl methacrylate (MMA) [23,24]. Furthermore, the PEEK surface dissolution improved resin penetration, strengthening the bond between PEEK posts and resin cement.

These findings were in accordance with other investigations examining the bond strength of the PEEK posts. **Attia, et al. (2022)** **[4]** , **ZHOU, et al.(2014)** [11], **CHMIDLIN, et al.(2010)** [25] . However, due to its potentially dangerous effects, It is best to avoid using sulfuric acid etching for PEEK surface treatment. [26]. Furthermore, the PEEK surface may deteriorate as a result of the prolonged etching, which could cause cohesive failures [27] Therefore, this conditioning technique should not be used chairside; It might well be suitable if the manufacturer has previously used it in an industrial setting to ensure safety.Furthermore, there are alternative surface treatment methods for PEEK than sulfuric acid that can be used to condition the PEEK surface such as sandblasting.

The results obtained were not consistent with that of **AlQahtani, et al.(2021)** [26] , who found that the values of the push-out bond strength for PEEK posts abraded by Al2O3 particles was greater than sulfuric acid etched posts and untreated posts.

The PEEK posts' surface roughness and microporosities are increased by airborne-particle abrasion with μm Al2O3, which enables micromechanical bonding with methyl methacrylate groups in resin cement.

Regarding the influence of surface treatments on the glass fiber posts, These findings of the current study exhibited significant improvement in push-out bond strength values after being treated with 9.5% Hydrofluoric acid etching followed by silane application more than other glass fiber post groups.

Vano, et al. (2007)[28], Mazzitelli, et al.(2008) [29], Mohsen C (2012) [1] , Abd El Wahab& El-Sharkawy (2017) [10] and **Alshahrani, et al.(2021) [30]** found that, The use of silane after etching with 9.5% hydrofluoric acid produced excellent results for the push out bond strength of glass fiber posts.

Hydrofluoric acid was used in this study because it affects the surface of fiber posts, resulting in surface roughness and increasing the surface area required for bonding. [31].

This study used silane application because silane coupling agents wet a substrate, reduce its surface tension, and increase its surface energy, making it more feasible for good bonding. Thus, a hydrophobic matrix (resin composite) can adhere to hydrophilic surfaces such as silica, glass, and glass-ceramics. [1,32]

According to **Abd El Wahab& El-Sharkawy (2017)** [10] the bonding between fiber posts and resin cement was also improved by hydrofluoric acid etching prior to silane application. Nevertheless, the glass fibres were severely damaged by this method, which might compromise the post's structural integrity. This is because hydrofluoric acid has a strong corrosive impact on the glass phase [33], and because of this, it is not suggested to employ these techniques in clinical settings because they may deteriorate the structural durability of the posts.

Bitter K, et al.(2006) [34] , **Vano, et al.(2007)** [28] and **Mazzitelli, et al.(2008)** [29] verified the same results. The use of hydrofluoric acid to condition fiber posts resulted in an improvement in post-to resin bond strength, but these investigations also found notable surface modification, ranging from microcracks to longitudinal fractures of the fiber layer. Because of this, it was impossible to provide broad recommendations for the application of hydrofluoric acid in the surface etching of aesthetic fiber posts.

Compared to the apical part, the coronal section's push-out bond strength was greater. **Bouillaguet, et al. (2003)** [35]**, Mallmann, et al. (2005)** [36]**,Ohlamnn, et al. (2008)** [37] **, Mumcu, et al. (2010)** [38] **and Attia, et al. (2022)** [4] agreed with this finding. The dentinal tubules direction and their high density in the coronal portions, as well as improved photo-activation over chemical activation alone, may be the causes. Alternatively, the cervical segments may be more accessible**.**

Among the limitations of this study, is the absence of mechanical and thermal cycling, which could be an important way to simulate clinical conditions that could affect the bonding strength. Future studies also ought to compare the effect of different resin cements.

The null hypothesis was rejected as there was a difference in the push out bond strength between glass fiber post system and PolyEtherEtherKetone (PEEK) posts after different surface treatments.

CONCLUSIONS

Data were collected, tabulated and statistically analyzed with the following conclusions:

(1) For PEEK posts, etching with 98 % sulfuric acid is the most effective surface treatment method to increase the bond strength but due to hazardous effects of sulfuric acid, sandblasting with aluminum oxide particles can be used instead of etching with sulfuric acid.

(2) For glass fiber posts, etching with 9.5 % hydrofluoric acid followed by silane application is the most effective surface treatment method to increase the bond strength but used with caution regarding the application time to avoid damaging of the post.

(3) The glass fiber post's bond strength to the root canals was higher than that of the PEEK posts.

Clinical recommendation:

PEEK posts can be utilized alternative to other post systems since it has a similar elastic modulus to dentin tissues and may achieve an acceptable bond strength to root dentin. So, it can reduce irreparable and irreversible problems of other post systems.

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