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Research Article

Influence of Various Surface Treatments on The Bond Strength of a Polyetherketoneketone (PEKK) Post Versus Fiberglass Post (An *In vitro* Study)

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Abstract

Purpose: To evaluate the influence of various surface treatments (Sandblasting, acid etching and silica- coating/silane) on the bond strength and mode of failure of PEKK post compared to fiber post.

Material and Methods: Thirty-six extracted mandibular first premolar were selected, and standardized post spaces have been prepared. The PEKK posts were milled from PEKK blank (Pekkton). The teeth were randomly distributed into four groups (n = 9): group A (Control group) prefabricated silanated fiber post, group B: PEKK posts sandblasting with silica modified Al_2O_3, then apply silane coupling agent, group C: PEKK Posts sandblasting with Al_2O_3, group D: PEKK posts etching with 98% sulfuric acid. All posts have been bonded using self-adhesive resin cement. Coronal section (2mm thickness) was obtained from each sample. Bond strength was then measured using push-out test. Modes of failure were evaluated by stereomicroscope. ANOVA One Way analysis of Variance (ANOVA) test was used followed by Tukey`s post hoc test for multiple comparisons. Failure mode of all groups was performed using by Chi square test.

Results: Control group recorded the highest push-out bond strength (17.32 ± 2.56 MPa) followed by aluminium oxide silica coated sandblasted group B (12.91 ± 1.95 MPa) then sulfuric acid etched group D (9.78 ± 0.96 MPa), while the lowest bond strength has been recorded with aluminium oxide sandblasted group C (9.38 ± 1.47 MPa). Comparison between different groups (Group A and all other groups\Group B and all other groups) revealed significant difference between them ($P < 0.05$). Group C and group D showed insignificant difference ($P > 0.05$). Also, comparison between different mode of failure was revealed significant difference only in adhesive mode between cement and post ($P < 0.05$). Group C was significantly the highest (44.4%) while group A was significantly the lowest (0%).

Conclusions: Glass fiber post reported higher push-out bond strength than PEKK post regardless different tested surface treatment modalities. Furthermore, the PEKK posts, blasted with silica modified aluminium oxide particles and coated with silane, showed a significant advantage for bonding, and may be promising surface treatment modality for PEKK post. Also, aluminium oxide blasting can be used as an alternative surface treatment to PEKK posts rather than etching with sulfuric acid.

Keywords: Post; PEKK; Push-Out; Bond Strength; Surface Treatment

Introduction

When a tooth undergoes endodontic therapy after suffering severe coronal structural loss, the tooth becomes more sensitive to masticatory forces [1,2]. The ultimate goal of dental treatment is to preserve natural teeth inside the oral cavity. After endodontic treatment, the tooth becomes brittle and likely to fracture, resulting in a decrease in crown strength, and cusp fracture or, in certain cases, root fragility. Anchorage within the teeth must be formed in order to reinforce the crown, and this could be provided by a post [3].

Numerous types of posts have been documented. Initially, posts constructed of cast metal alloys, prefabricated stainless steel, titanium, or precious alloys were employed [4]. Customized post and core systems are recommended for large, noncircular, or severely tapered canals, affecting the post's retention [5]. Because of the growing need for aesthetics, non-metallic post as zirconia or fiber post and core systems are being used more frequently than ever before [4,5].

Currently, with an emphasis on esthetics, composite and ceramic materials have been developed as options for posts and cores [3]. When a ceramic crown has a high translucency, the underlying core shade may have an effect on the final aesthetic outcome [5]. The increasing need for aesthetics, the application of non-metallic post and core systems have become more used than ever before e.g. zirconia and fiber posts [2].

Polyetherketoneketone (PEKK), a member of the polyaryletherketone (PAEK) family that was introduced to the market in 2000, is a semicrystalline linear thermoplastic polymer composed of ether and carbonyl groups connected by benzene rings. PEKK was marketed in dental field under the brand name Pekkton® (Cendres + Metaux). PEKK and PEEK (Polyetheretherketone) are both PAEKs [6,7]. According to the manufacturer, PEKK has similar compressive strength to dentinal tooth structure 246 MPa and 297 MPa respectively. However, PEKK is 80% stronger than PEEK. Also, the addition of TiO_2 has increased the wear resistance and hardness [7,8]. PEKK is a high-performance biocompatible polymer. It has a low elastic modulus, and excellent fracture resistance, making it an alternative to custom-made post systems [1,9,10].

For the post and core system's long-term success, bonding was considered important. In addition to their cosmetic advantages, PEKK can connect to tooth structure and the core, which enhances the creation of the monoblock [11-14].

Over the years, fiber posts are gaining popularity over zirconia or metal-based posts due to their enhanced bond strength to radicular dentin structure. Additionally, fiber posts are showing a strong bond between the fiber post's resin matrix and the resin cement [2,15].

Up to date, just few investigations on adhesion to PEKK have been reported. According to a previous research, enough bond strength values can be obtained with sulfuric acid (98%) etching, blasting with Al_2O_3, or tribochemical silica-coating, in comparison to weak bond strength achieved on polished surfaces [1,16].

Numerous test methods have been developed to determine the retention of posts. In comparison to pull-out test, push-out test mimic clinical situations. Push-out test proved to be capable of recording realistically weak bond strength for cements utilised to bond fiber posts. With the relative fragility of the post–dentine bond in mind, push-out test appears to record the most precise and reliable bond strength value of posts to radicular dentin structure [17,18].

The purpose of this study was to compare the bond strength and mechanism of failure of PEKK posts to fiber posts in order to assess the impact of different surface treatments, including sandblasting, acid etching, and silica- coating/silane. The null hypothesis was that there wouldn't be a significant difference in bond strength between fiberglass post and PEKK post with various surface treatments.

Materials and Methods

According to ethics committee approval [Approval number (6-10-19)], human mandibular first premolar teeth were extracted from Cairo University Dental Hospital because of periodontal and orthodontic reasons. A power analysis was designed to have adequate power to apply a 2-sided statistical test of the research hypothesis (null hypothesis) that there is no difference in bond strength between PEKK post with different surface treatments and fiberglass post. According to the results of Arslan, H., *et al*. -in which the (mean ± SD) value for both groups were (15.28 ± 3.39) and (19.73 ± 2.72)- and by adopting an alpha (α) level of 0.05 (5%), beta (β) level of 0.20 (20%) i.e. power = 80% and an effect size (d) of (1.45); the predicted sample size (n) was found to be a total of (36) samples

i.e. (9) for each group. Sample size calculation was performed using G*Power version 3.1.9.4.

Teeth were radiographed and chosen according to inclusion and exclusion criteria [19,20]. Inclusion criteria asfollowing: Teeth with straight roots, teeth similar size and shape, mean length of 21 ± 1 mm, and intact clinical crowns. Exclusion criteria as following: Teeth with open apex, teeth with root caries, teeth with cracks and root fractures, Teeth with internal/external resorption, and teeth with previous endodontic treatment. The teeth were sectioned 2 mm coronally to the cement-enamel-junction (CEJ), so that length of the root was standardized in all samples to be 14 ± 1 mm.

The root canals were instrumented using rotary system instrument (MPro, China). Irrigation with 5.25% NaOCl solution was administered with a 3 ml plastic syringe. Using cold lateral condensation technique, canal was filled with gutta percha and resin sealer (ADSEAL, Meta Biomed Co., Korea). Finally, eugenol-free temporary filling material was used to plug the canal openings. The roots were stored in 100% relative humidity for seven days at 37°C.

The roots were embedded vertically in epoxy resin blocks (KEMAPOXY 150, CMB International Co., Egypt), surrounded by plastic cylinder mold (14 mm internal diameter, 25 mm height); keeping the coronal 2 mm of the tooth above the epoxy resin block. External root surface was roughened to prevent separation from epoxy resin block during push-out test. A surveyor (Bredent BF-2,GmbH and Co.KG, Germany) was engaged to assure a precise centralized roots in resin blocks. After complete curing the epoxy resin, the block was pulled-out from the mold.

Removal of gutta percha was done using a Gates Glidden drills (Dentsply Maillefer, Switzerland) size 2 to size 3 to achieve post length of 10 mm. Post space preparation was finished by RelyX fiber post drill (3M ESPE, USA) size 2 (red coded). Milling machine hand-piece (Bredent BF-2, GmbH and Co.KG, Germany) was used to mount the drills. Also, any drills were introduced gradually to full working length directly to prevent heat generation. The canal was flushed using copious saline between each drill. After post space preparation, all samples were radiographed to ensure removal of all sealer and gutta-percha remnants.

All the 36 samples were divided randomly into four equal groups (n = 9)

- **Group A:** control group, prefabricated silanated fiber post.
- **Group B:** CAD/CAM PEKK post/surface treatment: sandblasting with 110 μm silica modified Al_2O_3, then apply silane coupling agent.
- **Group C:** CAD/CAM PEKK post/surface treatment: sandblasting with 110 μm Al_2O_3.
- **Group D:** CAD/CAM PEKK post/surface treatment: 98% sulfuric acid etching.

For Control group (n=9): All RelyX Fiber posts (3M ESPE, France) were marked at a distance of 10 mm. RelyX fiber post size 2 was tried. The post was disinfected with 70% ethanol for 1 min. and dried 1 min. prior to the cementation process [21].

For groups (B, C, D): Separating medium (MULTI-SEP Separating Medium; GC America) was applied to the canal before acrylic resin pattern fabrication. A powder-to-liquid ratio of 0.5g to 0.3ml was used. Autopolymerizing acrylic resin was placed on plastic pin (Duralay, Reliance Dental Manufacturing LLC, USA) that was inserted into the prepared canal. The core was built up and adjusted after final polymerization with tapered stone. The core was prepared to desired length of 5 mm.

The pattern was attached from the core by sticky wax to base. It was then sprayed with a scan powder (Renfert Scanspray, USA) and scanned with the extra-oral scanner (Medit Identica Hybrid 3D dental scanner). Final adjustment for pattern was done on CAD software (Exocad GmbH), which ensured adjusting the core length. The STL file of designed custom made post and core was transmitted to dental CAM software for programming and a five-axis dry milling machine (Dental milling machine K5, vhf, Germany) ready for milling the custom- made post and core from Pekkton ivory blank (Cendres + Métaux SA). After milling, the post was checked by sharp explorer.

Surface treatment of PEKK post

To standardize the sandblasting procedures, a special wooden holder was customized. (Figure 1)

Components of the wooden holder

- Base: 2cm thickness, 6.5cm width, and 18.5cm length.
- Two vertical boards for fixing the straight handpiece.
- Rubber cylinder attached through shank to straight handpiece. The post was fixed to the rubber by its friction with the core.
- Vertical board: 2cm thickness, 4cm width, 5.5cm length with notch to accommodate the sandblasting nozzle. The nozzle was adjusted 10 mm from the coronal part of the post at right angle according to manufacturer's instructions.

Straight handpiece (NSK EX-6B, Japan), which mounted on electric micromotor (Micro-NX Co., Korea), was fixed on the wooden holder to standardized the sandblasting procedures (at 1000 r.p.m.). A rubber cylinder attached through shank to straight handpiece. The post was fixed to the rubber by its friction with the core. The assembly was placed inside the sandblaster (Renfert, BASIC eco, Germany). (Figure 2)

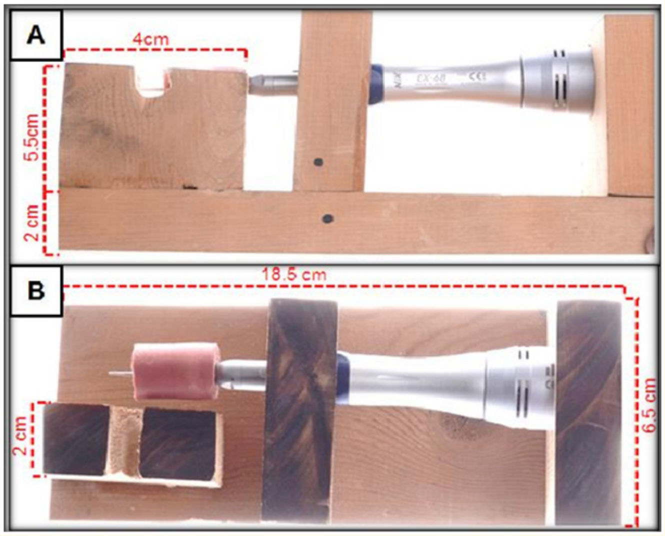

Figure 1: Wooden holder. A-lateral view. B-top view.

Figure 2: Wooden holder inside sandblaster of Renfert.

Group B CAD/ CAM fabricated PEKK post (n=9): Firstly, the posts were sandblasted with 110 µm Al_2O_3 (Rocatec Pre, 3M ESPE, Germany) using sandblasting machine for 15 sec. Then, the posts blasted with silica modified 110 µm Al_2O_3 particles (Rocatec Plus, 3M ESPE, Germany) for 15 sec. The posts were sandblasted at a pressure of 2 bars, right angle to the nozzle, and 10 mm working distance for 15 sec. Finally, the silane coupling agent (3M ESPE, USA) was applied.

Group C CAD/ CAM fabricated PEKK post (n = 9): The posts were sandblasted Rocatec Pre. The posts were sandblasted at a pressure of 2 bars, right angle to the nozzle, and 10 mm working distance. The surface of the post was sandblasted at right angle to the nozzle at working distance of 10 mm for 15 sec. Then, they were cleaned with compressed air oil free and water free for 15 sec to remove any loose particles.

Group D CAD/ CAM fabricated PEKK post (n = 9): The posts immersed in dappen dish filled with 98% sulfuric acid (Brand Chemical, Egypt) for 60 sec. at room temperature. Then, the posts rinsed for 60 sec. and dried with air oil free for 20 sec [22].

Post cementation

Irrigation protocol: The canal was flushed with 3ml 0.9% saline solution. Then, root canal disinfection was done with 3ml 5.25% NaOCl solution. This was followed by flushing the canal with 3ml 0.9% saline solution. And finally the canal was dried with paper points. The auto-mixing syringe of the dual-polymerizing self-adhesive (Relyx U200, 3M ESPE, Germany) was used. With the use of an endo tip inserted into the canal, the cement was gently injected.

The post was then placed into the canal. A specially designed loading device was used to standardize the load application (a static load of 1 kg for 5 min.). The cement was then light-cured with Bluephase LED polymerization light cure unit (Ivoclar, Vivadent, Liechtenstein) at 1,200 mW/cm2 for 40 sec. All samples were stored in 0.9% saline at room temperature for seven days before testing to ensure complete polymerization of resin cement.

Push-out bond testing

Each epoxy resin block was mounted on the holding device of a low speed saw (Isomet 4000, USA) and cut perpendicular to the long axis of the sample under copious water coolant. The first 1 mm of each sample below CEJ was discarded. Then, one slice (coronal) 2 mm thickness for each sample was obtained. By using digital caliper (INSIZE, China), the thickness was verified.

The sections have been mounted to a universal testing machine (Instron 3345, England) with the coronal side facing toward the jig. A customized loading fixture was constructed. The stainless-steel plunger (1.3 mm) has been directed exactly to the middle of the post without any contact to surrounding dentin surface (Figure 3). The compressive load have been applied in apico-coronal direction (crosshead speed of 1 mm/min). The peak failure load was recorded in newtons (N) using the computer software (bluehill instron, England) and converted to megapascals (MPa) by dividing the failure load (in N) by the bonded area (in mm2) [23,24].

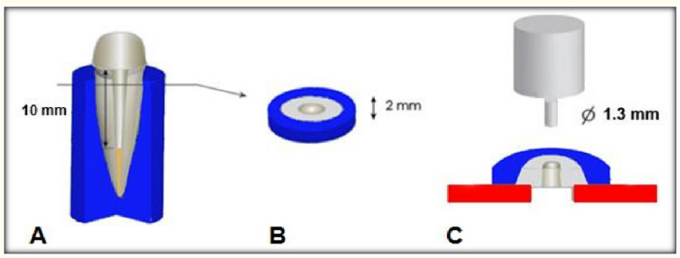

Figure 3: Diagram showing the preparation and push-out testing. A, epoxy resin block. B, coronal section after preparation. C, loading application in Instron Testing Machine.

Assessment of mode of failure

Following the push-out bond strength test, the failure mode of all debond specimens was evaluated by same operator using a stereomicroscope 70x (Nikon MA 100 stereomicroscope, Japan). Failure modes were classified as follows according to Güven., *et al*. (2020): Adhesive failure between dentin and cement (DC), adhesive failure between cement and post (CP), cohesive failure within cement (C) cohesive failure within the post (P), and mixed (adhesive and cohesive) failure [10].

Statistical analysis

Statistical analysis was performed using SPSS 20®, Graph Pad Prism® and Microsoft Excel 2016. Data were explored for normality by using Shapiro Wilk and KolmogorovSmirnov normality test which revealed that all data were parametric data (P-value > 0.05). In push out strength comparison between four groups was performed by using One Way analysis of Variance (ANOVA) test followed by Tukey`s post hoc test for multiple comparisons. But in mode of failure, comparison between different percentages of failure mode in all groups was performed by Chi square test.

Results

Push out bond strength

Comparison between different groups revealed significant difference in means with different superscript letters as P < 0.05 (Group A and all other groups\Group B and all other groups). Also, there was insignificant difference in means with the same superscript letters as P > 0.05 (Group C and group D) (Table1).

Groups	Post material	Surface treatment	Count	Mean	SD	P value
Group A (control)	Prefabricated silanated fiber post	Silanated	9	17.32[a]	2.56	0.001*
Group B	CAD/CAM PEKK fabricated post	Sandblasting with silica modified Al_2O_3 particles+ silanization	9	12.91[b]	1.95	0.001*
Group C	CAD/CAM PEKK fabricated post	Sandblasting with 110 u AL_2O_3 particles	9	9.38[c]	1.47	0.001*
Group D	CAD/CAM PEKK fabricated post	Chemical acid etching by 98% sulfuric acid	9	9.78[c]	0.96	0.001*

Table 1: Statistical data analysis of push-out bond strength of tested groups.

*significant difference P < 0.05.

Means with different superscript letters were significantly different (P<0.05).

Means with the same superscript letters were insignificantly different (P>0.05).

Mode of failure

The classification of mode of failure was related to the resin cement remaining on the tested sample surface. Adhesive failure between dentin and cement was detected when no resin cement relined whole the canal, while the resin cement was found surrounding the post. (Figure 4a) Adhesive failure between cement and post was detected when resin cement relined all surfaces of the canal, while no resin cement was found surrounding the post. (Figure 4b) Mixed failure (association between adhesive and cohesive failure) was detected when resin cement remnants have been found attached to the post and the canal in irregular pattern. (Figure 4c)

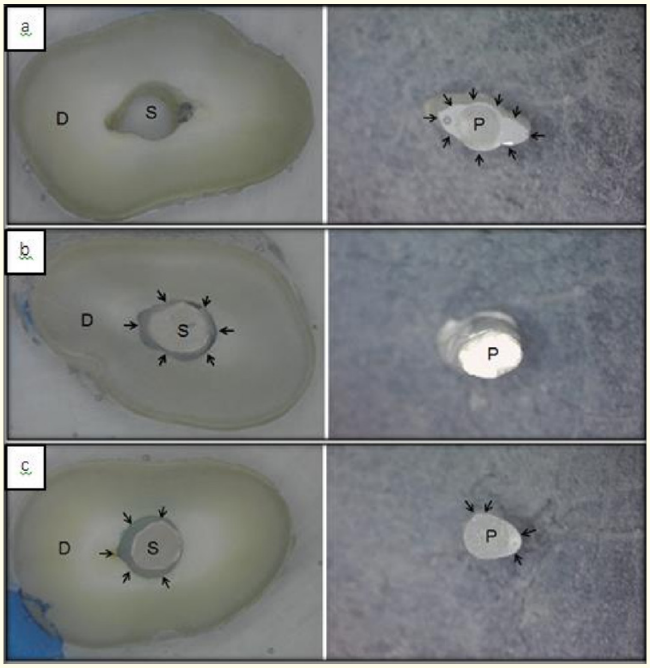

Figure 4: Dentin (D), post space (S), post (P), resin cement (arrows).

Moreover, comparison mode of failure between different groups was revealed significant difference only in Adhesive CP as P <0.05 (group C was significantly the highest while group A was significantly the lowest) (Table 2).

The adhesive failure modes between PEKK post and cement were found mainly in group C (55.5%) followed by group D (44.4%). Meanwhile, group B showed the least adhesive cement/post mode of failure (33.3%) with no significant difference between them. Whereas, fiberglass post reported no adhesive cement post mode of failure.

Correlation between push out bond strength and mode of failure

The percentage of adhesive cement/post mode of failure tend to decrease as the push-out bond strength increases, with zero % in fiberglass post which reported the highest push-out bond strength.

Discussion

The null hypothesis was analyzed in the current study, showing no significant difference in the bond strength between PEKK post with different surface treatments and fiberglass post, thus; the tested null hypothesis was rejected based on the results of the study. In this study 36 single-rooted human mandibular first premolar teeth were used to simulate the clinical condition. They are prefer-

	Adhesive DC		Adhesive CP Groups		Cohesive C Mixed				Cohesive P		P value
	Count	%	Count	%	Count	%	Count	%	Count	%	
Group A (control)	5^{aA}	55.5	0^{bA}	0	0^{b}	0	0^{b}	0	4^{aA}	44.4	0.001*
Group B	4^{aA}	44.4	3^{aB}	33.3	0^{b}	0	0^{b}	0	2^{aA}	22.2	0.02*
Group C	1^{aA}	11.1	5^{bB}	55.5	0^{a}	0	0^{a}	0	3^{abA}	33.3	0.001*
Group D	2^{abA}	22.2	4^{aB}	44.4	0^{b}	0	0^{b}	0	3^{abA}	33.3	0.02*
P value	0.055		0.01*		---		----		0.33		

Table 2: Counts and percentages of different modes of failure in all groups.
*significant difference P < 0.05.
Means with different superscript letters were significantly different as P < 0.05
(Lower case letters in row/uppercase letters in column).
Means with the same superscript letters were insignificantly different
(P > 0.05) (Lower case letters in row/uppercase letters in column).

able over bovine root, as human natural teeth have more reliable results. The inclusion criteria selected was that to be similar in size and shape, and length 21 ± 1mm to standardize microstructure of dentin [19,25]. The teeth were stored in a 0.9% standardized saline solution in glass container at room temperature until the experimental start to prevent dehydration and brittleness of the root canal [2,20].

Cold lateral condensation technique was selected to avoid denaturation of dentin collagen through the heat, which may have adverse effect on bonding strength of the resin cement [2,19,26,27]. The teeth were embedded vertically and centrally in standardized epoxy resin mold to help in mounting the samples on a universal testing machine and to later help in accurately cutting the slices by Isomet. Post space preparation was done by Gates Glidden drills, then RelyX fiber post drill size 2 was used for finishing the preparation. The preparation was achieved by mounting the drill on handpiece of milling machine BF-2 to ensure standardization the preparation of post space, and to ensure it to be perpendicular to CEJ, with no undercut for all teeth. The gradual increase in drills size and the usage of copious irrigation between the drills was done to decrease heat generation [5,26].

RelyX fiber post was selected in the current study as the control group to ensure adequate bonding. This was in agreement with Song., *et al.* who recorded the highest bond strengths with RelyX fiber posts and RelyX U200 cement [1,19,20,21,28]. For groups B,C, D custom made PEKK post was selected due to similar compressive strength (246MPa) to that of dentine (297MPa) and its lower elastic modulus (5.1GPa) than that of dentin. As Lee., *et al.* in 2017, showed PEKK posts had superior fracture resistance and a more uniform distribution of stress than both metal and fiber posts, the difference being attributable to PEKK's extremely low elastic modulus (act as stress breaker) [29].

In the current study, we have attempted to improve the bond strength through appropriate combination of micromechanical and/or chemical surface treatments and silane [30]. For standardization of sandblasting parameters, a wooden holder was fabricated, and the nozzle was adjusted 10 mm and centralized at the coronal part of the post, with a pressure of 2 bars, for 15 sec., at right angle to the post. Sulfuric acid with 98% concentration (60 sec.) for etching group D PEKK post was selected [22]. This was in agreement with Fokasa., *et al.* who reported reliable bond strength with similar concentration.

It is important to mention that dual cure self-adhesive resin cement was used in this study for cementation of all posts. Dual curing cement was selected as it is supposed to adequately polymerize in deeper areas of the post space. This was in agreement with Elbanna., *et al*. [19,20,24]. The coronal third was selected to be tested, as the main point of the current study to evaluate the bonding strength of the PEKK post [2,24-27]. As Oskoee., *et al*. reported no significant variation in bond strength was observed between root sections when using any one of the cementation techniques [27]. To ensure standardization; coronal slices were obtained using Isomet 4000 and thickness was verified by digital caliper [2,24]. In the current study, Push out test was used to evaluate the bond strength in agreement with Oskoee., *et al.* [10,27].

Regarding the results of this study; it was found that the control group A has recorded the highest push-out bond strength (17.32 ± 2.56MPa), followed by the aluminium oxide silica coated sandblasted group B (12.91 ± 1.95 MPa), then the sulfuric acid etched group D (9.78 ± 0.96 MPa), while the lowest bond strength was recorded in the aluminium oxide sandblasted group C (9.38 ± 1.47 MPa). A significant difference between all groups was revealed, except for groups C and D, where no significant difference was found.

The control group of fiber posts showed the highest bond strength, which is in accordance with Durski., *et al.* (2015) [19]. This may be attributed to the combination between the pre-silanated RelyX fiber post and RelyX U200 resin cement which was applied by elongation tip. This was in disagreement with Song., *et al*. who found that the fiber posts show less bond strength than treated PEKK posts; also, Güven., *et al*. who found that the fiber posts showed less bond strength than untreated custom-made PEKK posts [1,10]. Song., *et al.* reported a different result due to the different methodology and absence of a human teeth substrate [1].

PEKK posts (group B), which were blasted with 110 µm Al_2O_3 silica coated and treated with silane, showed the highest bond strength in all PEKK posts groups. This result was consistent with Fuhrmann., *et al*. (2014), Song., *et al*. (2018), and Fokas., *et al*. (2019) [1,22,30]. This can be explained by the infiltration of silane into rough surfaces. In Song., *et al*. study, this finding could be explained by the addition of a chemical bonding through silica coating and silane treatment. The covalent bond formed by the silanol group of the silane coupling agent and the silica-based filler in resin cement; as well as the covalent bond formed by the silanol group of the coupling agent and the hydroxyl(–OH) group on the silica-coated PEKK post; appeared to have contributed to the improvement of the bond [1].

However, the PEKK posts (group C), which were blasted with 110 µm Al_2O_3, showed the least bond strength in all PEKK posts groups. This finding was in agreement with Song., *et al*. and Fokas., *et al.* who showed that the bond strength of the sandblasted PEKK posts was lower than which had tribochemical silica-coating (group B). According to these studies; the sandblasting of PEKK posts have showed irregular grooves on the rough surface of the PEKK, which was penetrated by resin cement to achieve a micromechanical interlock [1,22].

The difference found between the etched group D and the blasted group C may be attributed to the sulfonation effect of sulfuric acid which enhances the bonding strength, however; this difference was insignificant. This was in agreement with Fokas., *et al.* (2019) [22]. Furthermore, the lower bond strength of sulfuric acid PEKK post may be explained by results of Wang., *et al.* (2021) who reported that etching PEKK post using sulfuric acid for 60 sec. resulted in greater etch depth that were not filled with bonding material [34].

In the present experiment; for fiberglass post, the most common mode of failure was the adhesive failure DC, which was consistent with Oskoee., *et al.* and Güven., *et al.* studies [10,27]. The control group of fiber posts showed that 55.5% of the failures occur between the dentin and cement, which was in accordance with Oskoee., *et al*. as well as Spazzin., *et al* [27,32]. On the other hand; this finding was opposed to Perdigao., *et al*. who found that most adhesive failures were between the fiber post and resin cement [15]. These conflicting results can be explained by the variability of the research methodologies and materials. This finding was also opposed to Güven., *et al*. who reported a cohesive cement failure in prefabricated posts; which can be attributed to using extracted maxillary incisors with size 1 prefabricated post, which have increased cement gap [10].

The results of failure mode of PEKK posts were in agreement with Fokas., *et al*. the adhesive failure mode was the predominant one for all samples [22]. Also; the modes of failure of PEKK posts (group B); which had tribochemical silica-coating; were predominantly adhesive failure DC (44.4%). In contrary; the PEKK posts (group C and D); which were blasted and etched respectively; showed a predominant adhesive failure between the cement and the post (55.5% for group C and 44.4% for group D). Sakihara., *et al.* stated that etched PEKK specimens had adhesive failures and mixed failures, Fuhrmann et al. explained that complete cohesive failure absence is attributed to the high bonding strength between the cement and the post, which doesn't exceed the bonding between the molecules of the cement and PEKK [6,30]. The results of mode of failure were in accordance to Attia., *et al*. in 2020 who tested treated PEEK which belongs to PAEK family [18].

Regarding the study's limitations, no mechanical and thermal cycling was performed which could play a significant role in simulating the clinical circumstances that might have an impact on the bonding strength. Future research should also compare the effect of various resin cements.

Conclusion

Within the limitations of the present study, it may be stated that

- Glass fiber post reported higher push-out bond strength than PEKK post regardless different tested surface treatment modalities.
- The PEKK posts, blasted with silica modified aluminium oxide particles and coated with silane, showed a significant advantage for bonding, and may be promising surface treatment modality for PEKK post.
- Aluminium oxide blasting can be used as an alternative surface treatment to PEKK posts rather than etching with 98% sulfuric acid.

Recommendation

- Further investigations on the durability of the bond strength of PEKK posts after mechanical and thermal cycling.
- Further studies on the evaluation the bond strength of PEKK posts with different types of resin cements.
- Clinical studies evaluating the actual performance of PEKK post.

Clinical Implication

In clinical practice, PEKK post can be used instead of other post systems since it can reduce irreversible complications due to achieve adequate bond strength to root dentin and its similar elastic modulus relative to dentin tissues.

Conflict of Interest

The authors declare no conflict of interest.

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