ORIGINAL ARTICLE / *ARTICLE ORIGINAL*

Prosthodontics / *Prothèse Fixée*

INVESTIGATION OF FRACTURE RESISTANCE WITH DIFFERENT DIAMETERS OF POLYETHERKETONEKETONE POSTS AND CORES MATERIAL: A PILOT STUDY

Maya Kabbara[1] | Ryan Harouny[2,3] | Habib Rahme[1]

Objectives: The primary objective of this study is to investigate the resistance to fracture of Polyetherketoneketones PEKK, used as post and core by fabrication in different diameters in the canal, and comparing the test results for each group.

Methods: Thirty extracted mandibular premolars were selected, endodontically treated and prepared to receive the post and cores milled from polyetherketoneketone disk. The specimens were randomly divided into five groups (n = 6) respectively: group 1 received pekk post with diameter = 0.70 mm, group 2 received pekk post with diameter = 0.90 mm, group 3 received pekk post with diameter = 1.10 mm, group 4 received pekk post with diameter = 1.50 mm, and group 5 received pekk post with diameter = 1.70 mm. All the posts were cemented using a self-adhesive resin cement . Fracture resistance was tested using a universal testing machine, failure patterns were then observed visually and radiographically. For the fracture resistance test, the Universal Testing machine employed the load cell of 10KN and the speed of the cross head of 1mm/min. Data was analyzed using Oneway analysis of variance (ANOVA) followed by Tukey post-hoc test in order to determine significant differences among groups and the materiality threshold was set at $\alpha = 0.05$.

Results: Statistical analysis revealed that the observed differences among the five groups were not significant. None of the PEKK posts caused any fracture in the root, and this observation was visually and radiographically confirmed across all groups.

Conclusions: The dentist will be able to turn the diameter of the PEKK post and core as thin as 0.70mm till 1.70mm depending on the clinical requirement with no risk of root fracture, as specified by the guidelines of this research.

Keywords: CAD/CAM, Esthetic post and core, High performance polymer, PEKK, Fracture resistance, Universal Testing Machine

Corresponding author:
Maya Kabara, e-mail: maya.kabbara@net.usj.edu.lb

Conflicts of interest:
The authors declare no conflicts of interest.

1. Department of Prosthetic Dentistry, Faculty of Dentistry, Saint-Joseph University, Beirut, Lebanon, Phone: +9613619860, e-mail: maya.kabbara@net.usj.edu.lb (M.K.); habib.rahme@usj.edu.lb (H.R.)
2. Department of Restorative Dentistry, Faculty of Dentistry, Saint-Joseph University, Beirut 1107/2180, Lebanon; ryaneliott.harouny@net.usj.edu.lb (R.H.)
3. Craniofacial Research Laboratory, Division of Biomaterials, School of Dentistry, Saint-Joseph University, Beirut 1107 2180, Lebanon

ÉTUDE DE LA RÉSISTANCE À LA RUPTURE AVEC DIFFÉRENTS DIAMÈTRES DE FAUX MOIGNONS EN POLYÉTHERCÉTONECÉTONE: UNE ÉTUDE PILOTE

Objectifs: L'objectif principal de cette étude est d'étudier la résistance à la rupture des polyéthercétonecétones PEKK, utilisées comme faux moignon (FM) dans différents diamètres, en comparant les résultats des tests pour chaque groupe.

Méthodes: Trente prémolaires mandibulaires extraites ont été sélectionnées, traitées endodontiquement et préparées pour recevoir le tenon et les noyaux fraisés à partir d'un disque de polyéthercétonecétone. Les spécimens ont été répartis au hasard en cinq groupes (n = 6) respectivement : le groupe 1 a reçu un FM d'un diamètre de 0,70 mm, le groupe 2 a reçu un FM d'un diamètre de 0,90 mm, le groupe 3 a reçu un FM d'un diamètre de 1,10 mm, le groupe 4 a reçu un FM d'un diamètre de 1,50 mm, et le groupe 5 a reçu un FM d'un diamètre de 1,70 mm. Tous les FM ont été cimentés à l'aide d'un ciment résine autocollant. La résistance à la rupture a été testée à l'aide d'une machine d'essai universelle, les modèles de défaillance ont ensuite été observés visuellement et radiographiquement. Pour le test de résistance à la rupture, la machine Universal Testing est utilisée avec une cellule de charge de 10KN et une vitesse de la tête de 1 mm/min. Les données ont été analysées à l'aide d'une analyse de variance : One way ANOVA suivie d'un test post-hoc de Tukey afin de déterminer les différences significatives entre les groupes et le seuil de signification a été fixé à $\alpha = 0,05$.

Résultats: L'analyse statistique a révélé que les différences observées entre les cinq groupes n'étaient pas significatives. Aucun des tenons PEKK n'a provoqué de fracture de la racine, et cette observation a été confirmée visuellement et radiographiquement dans tous les groupes.

Conclusions: Le dentiste sera capable de tourner le diamètre du tenon et du FM, PEKK aussi fin que 0,70 mm à 1,70 mm en fonction des exigences cliniques sans risque de fracture radiculaire, comme spécifié par les directives de cette recherche.

Mots clés: CAD/CAM, faux moignon esthétiques, polymère haute performance, PEKK, résistance à la rupture, machine d'essai universelle

Introduction

The challenge of restoring teeth in the esthetic zone is a delicate process, often met with the increasing esthetic demands of patients which compels us to restore with all ceramic crowns which are highly translucent and allow the transmission of light. These restorations offer aesthetic benefits and impressive durability, making them a favorable substitute for conventional ceramo-metallic crowns [1]. In today's society, where aesthetics are gaining more prominence, the metal-ceramic system, although proven to be clinically reliable over a long period, no longer provides the desired level of mimicry and biocompatibility. However, the advancements in computer-aided design and computer-aided manufacturing (CAD/CAM) systems in the past twenty years have fueled the progress of new all-ceramic materials [2]. However, restoring teeth in the esthetic zone often confront the following obstacle: the post and core step. Currently, metal posts are commonly used to restore endodontically treated teeth in the corono-radicular portion, owing to their adaptability to the root canal morphology and mechanical strength; nevertheless they do not meet the esthetic criteria. Furthermore, esthetically pleasing materials such as fiber posts and zirconia posts have been addressed in the literature, and despite their esthetic advantages, they do not cover all the essential functional properties [3]. Moreover, recent materials in innovative dentistry require the properties of mimicking natural tooth structure, biocompatibility, being esthetically pleasing, and low plaque affinity. All of these contribute to restoring dental structures, and satisfying patients with esthetic demands [3].

Lately Polyetherketoneketone, which is defined as a high-performance thermoplastic polymer has been launched in advanced dentistry as the most recent post and core material, possessing both beneficial esthetic and biomechanical features.

PEKK can be used as post and core underneath all ceramic crowns owing to its white, esthetic color in the esthetic zone. This is beneficial for esthetic cases since it allows the translucent appearance and transmission of light, as compared to metal posts [4].

This recent PEKK biomaterials is attractive to the post and core system owing to its suitable production which is via CAD-CAM milling and pressing, beneficial mechanical properties, and high shock-absorbing feature [5,6]. PEKK exhibits beneficial biomechanical performance which is superior to that of metal and fiber posts, particularly higher tooth fracture resistance [5]. In a study conducted by Lee et al. he demonstrated long term biomechanical performance of PEKK as a material for post and core. His study concluded that using PEKK as a post and core material provides us with a high fracture resistance restoration. Hence PEKK post and core has shown a satisfactory stress distribution at the level of intraradicular portion, demonstrating less risk for root fracture than conventional post and core systems, as revealed in the FEA research done by Lee et al [5].

In addition, PEKK biomaterial has recently qualified with other golden standard materials for post and core this is further elaborated in its long-term biomechanical performance [5,7]. Moreover, in comparison to rigid biomaterials like zirconia and metal posts, PEKK possesses a low Young's modulus of 4 GPa, and similar to bone in its elasticity, delivering a cushioning effect and a decrease in stress transmitted to abutment teeth [8,9]. Despite that PEKK is becoming more commonly used in the clinic, merely a few investigations are presented aiming at the use of this biomaterial for CAD-CAM restorations.

In brief, in comparison to fiber posts it is monolithic and it conforms to the root canal morphology due to CAD/CAM technology, which will eliminate the risk of having 2 different non-homogeneous materials in the coronal part of any tooth reconstruction, such as in fiber post on one hand and it conserves tooth structure by respecting the root anatomy during its fabrication on the other hand [3].

When compared to metal posts its modulus of elasticity is more similar to dentin and its esthetic characteristics is much better [5].

Therefore, it can be concluded that an in vitro pilot study is needed to investigate the mechanical behavior and resistance to fracture of PEKK under different post diameters. The objective is to determine the limitation of its use for 5 different diameters, and demonstrate which minimal diameter is unable to withstand the occlusal forces, and which maximal diameter is available in order not to fracture the root. The null hypothesis investigated in this research is that there is no significant difference in the resistance to fracture and in the mode of fracture of teeth restored with PEKK posts and cores with respect to the different diameters of the post.

Materials and Methods

Ethical committee acceptance number: USJ-2022-236

Sample Description

Thirty intact, non-carious human mandibular first premolar teeth that were going for orthodontic extraction were used for the present study. The mandibular first premolar teeth having a single root and a single right canal extracted showing no restorations, caries, fractures, fissures, and no root canal treatment which would influence fracture resistance, were gathered for the research. They were stored in a 0.5% chloramine solution for a period of time no longer than 2 months. The thirty teeth must have approximately the same lengths, calculated from JEC to apex on buccal side, the same mesiodistal and buccolingual diameter calculated at JEC using a vernier caliper and pulp chambers of the same shape. Maximal deviations of one millimeter in diameter and length was accepted. Any other teeth not meeting these criteria were excluded from the study. Teeth were kept in saline solution for up to two months before the investigation. To simulate the periodontium: the teeth roots were coated by a layer of liquefied wax and each sample were inserted in a self-curing acrylic resin, which are poured into molds, two millimeters below JEC positioned perpendicular to tooth long axis utilizing a parallelizer to mimic bone level and offer support for the teeth when directing loads.

The specimens were randomly divided into five groups (n = 6) respectively: group 1 received pekk post with diameter = 0.70 mm, group 2 received pekk post with diameter = 0.90 mm, group 3 received pekk post with diameter = 1.10 mm, group 4 received pekk post with diameter = 1.50 mm, and group 5 received pekk post with diameter = 1.70 mm.

Sample Preparation

A standardized root canal treatment on all teeth was employed in a similar manner. The working length for all teeth was set at 0.5 mm from the apex. The canals were cleaned and shaped with #10 and #15 K files to working length, with irrigation. RACE EVO (FKG DENTAIRE) 4% Taper were primarily selected to remove a conservative amount of root dentin and shape the root canals with irrigation with 5.25% sodium hypochlorite. Afterwards, the canals were dried by paper cones and obturated with gutta percha by lateral condensation and sealed with zinc oxide eugenol cement.

Crown Preparations

The teeth preparations were carried out in a standardized manner, i.e. the preparations were standardized with a taper of 6 ° and chamfer margins of 1mm (diameter), at a distance of 0.5 mm above the JEC and a ferrule effect of 1.5 mm (height), using a parallelizer. Then the thickness of the dentin walls were checked with a caliper. The samples had a dentinal thickenss of 2 mm. Teeth with dentin thickness less than 2 mm were replaced.

Post Space Preparation

Then all the teeth had the same post space preparation to the same length such that all posts and cores of the restorations have identical lengths. As for the diameter, it was different for each group (Figures 1 and 2).

In this study we used Mani Gates Glidden Drills (Mani, Inc, Kiyohara Industrial Park, Japan) and Mani Peeso Reamers (Mani, Inc, Kiyohara Industrial Park, Japan).

Figure 1. AD/CAM Milled PEKK Post & Core at different diameters. Figure 2. PEKK post with no gap inside the root canal

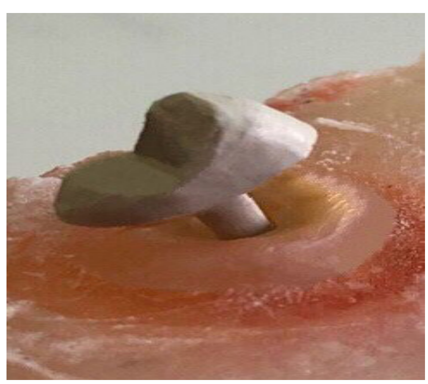

Figure 2. PEKK post with no gap inside the root canal

Size of Mani Glidden Drill:

#1 is 0.5 mm, #2 is 0.7 mm, #3 is 0.9 mm, #4 is 1.10 mm, #5 is 1.3 mm and #6 is 1.5 mm [10].

Size of Mani Peeso Reamers:

Diameter for size #1=0.70, #2 =0.90, #3 =1.10, #4 =1.30, #5 =1.50, #6 =1.70 [11].

According to these sizes available in the market, the lab protocol was as follows:

Group 1: Using Peeso Reamer #1 and Gates-Glidden #2 to get a diameter of 0.70mm for group 1.

Group 2: Using Peeso Reamer #2 and Gates-Glidden #3 to get a diameter of 0.90mm for group 2.

Group 3: Using Peeso Reamer #3 and Gates-Glidden #4 to get a diameter of 1.10mm for group 3

Group 4: Using Peeso Reamer #5 and Gates-Glidden #6 to get a diameter of 1.50mm for group 4

Group 5: Using peeso reamer #6 and Gates-Glidden #6 to get a diameter of 1.70mm for group 5

All the prepared canal spaces were coated with a minimal amount of die lubricant (Picosep, Renfert, Hilzingen, Germany). Resin patterns were directly created (Pattern Resin, GC America, Alsip IL, USA) with a consistent length of 4 mm above the ferrule, while maintaining a 30-degree angle between the buccal cusp slope and the tooth's long axis, which was verified using a dental surveyor. The resin patterns were then sprayed with a scanning powder (Denu Easy Scan, Hdient, Seoul, Korea) and scanned using a laboratory scanner (Ceramill map400, Amann Girrbach, America). After the scanning process, the collected digital data were transferred to a specialized digital software (Ceramill mind, Amann Girrbach, America), which was followed by the use of a computer-aided manufacturing (CAM) software (Ceramill motion 2, Amann Girrbach, America) to create the milling sequence for PEKK post and cores. The parameters of the software including the following; uniform cement thickness amongst all the groups, and no use of compensation step for the cutter tool diameter. Subsequently, the canal spaces were cleaned with sodium hypochlorite (Medicinos linija, UAB Aviacijos str. 28. Siauliai, LT-77103, Lithuania), rinsed with distilled water, and dried using paper points

(Dia Dent International Group, Chungcheongbuk-do 28161, Korea). The fitting of the PEKK posts and cores was evaluated with Oranwash Light Body (Zhermack, Italy) to obtain the acceptable fit along the radicular and coronal part, and little adjustments were needed with round end taper chamfer diamond bur (Mani, Japan). Then the PEKK post and cores were treated with silane RelyX® Ceramic Primer (3M ESPE, Seefeld -Germany) and cemented using a self-adhesive resin cement, following the recommendations provided by the manufacturer (PANAVIA™ SA CEMENT Plus Automix, Kurashiki, Japan). Elongation tips were used to accurately place the cement within the canal, preventing the formation of air bubbles. After a light polymerization process (Light Cure LED C, Woodpecker, China) for 10 seconds on the post's tip, any excess cement was removed.

Table 1. Materials used in this study by material and manufacturer

Material	Manufacturer	Composition	LOT Number
Pekkton® ivory	Cendres et Métaux, Bienne, Biel/Bienne, Switzerland	Polyetherketoneketone: 80% Titanium dioxide fillers: 20%	0000356002
Panavia™ SA Cement Plus Automix	Kuraray Noritake Dental Inc, Kurashiki, Japan	(Bis-GMA), (TEGDMA), Hydrophobic aromatic dimethacrylate, Hydrophilic aliphatic dimethacrylate, Initiators, Accelerators, Silanated barium glass filler, Silanated fluoroalminosilicate glass filler, Colloidal silica Bisphenol A, , Silanated barium glass filler, Silanated alminium oxide filler, Accelerators, dl-Camphorquinone, Pigments	8Q0065

Fracture Resistance Test

For the fracture resistance test, the Universal Testing machine employed the load cell of 10KN and the speed of the cross head of 1mm/min. The main focus of this pilot study was the fracture resistance of PEKK posts and cores, and no crowns were tested in this pilot study. The fracture resistance test was conducted on 30 teeth with the aid of a universal machine (YLE GmbH Waldstraße Bad König, Germany). This allowed the application of loads on each post diameter until fracture. Charges were loaded at a 45° angle with a knife-edge blade placed perpendicularly in the tooth long axis, 2mm from the tip of buccal cusp towards the central fossa at a crosshead speed of 1 mm/min on each sample until fracture occurred, according to ISO/TS 11405:2015. The load resulting in fracture were calculated in Newton. All coded specimens were individually mounted in a 45° angulation custom-made jig that secured to the lower fixed compartment of the universal machine (YL-01, Germany). The load was applied using a custom steel rod with sharp end, placed palatally 3 mm below the incisal edge of the specimen (Figures 3 and 4).

Figure 3. Custom-made jig to fix specimen at 45 degrees angle

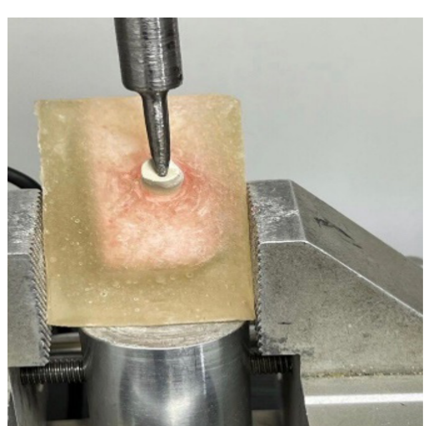

Figure 4. Fracture resistance test

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, NY, USA). Descriptive statistics of the fracture resistance (N) for the five groups were calculated and presented as means ± standard deviations, medians (interquartile ranges), and minimum/maximum values. The Shapiro-Wilk test was used to evaluate the normality of distribution of the quantitative variable. And since the fracture resistance was not normally distributed, the Kruskal-Wallis test was used to compare values among groups. The level of significance was set at 5% and the test was two-tailed.

Results

The clinical and radiological examination results have shown no tooth fracture in all groups (Figure 5). Table 2 and Figure 6 present a summary and comparison of the fracture resistance results across groups. Regarding the mean fracture resistance, the highest value was observed in group 1 (292.33 ± 137.14 N) and the lowest in group 4 (245.67 ± 64.48 N). When comparing the median, the highest value was observed in group 5. However,

Table 2. Fracture resistance (N) among groups.

	Mean ± SD	Median (Q1 – Q3)	Minimum	Maximum	*p*-value
Group 1 (0.7 mm)	292.33 ± 137.14	261 (192.25 – 379.75)	157	547	
Group 2 (0.9 mm)	270.5 ± 132.76	275 (145 – 344.75)	130	500	
Group 3 (1.1 mm)	285.67 ± 46.98	278 (248 – 328.5)	230	354	0.891 *ns*¶
Group 4 (1.5 mm)	245.67 ± 64.48	231.5 (184.5 – 319.75)	177	331	
Group 5 (1.7 mm)	280.17 ± 80.07	281 (205 – 339.75)	181	408	

SD = standard deviation; Q1 = first quartile; Q3 = third quartile; ns = non-significant; ¶: Kruskal-Wallis test.

Figure 5. Fracture at the coronal level of PEKK post, leaving no fracture at the level of the tooth.

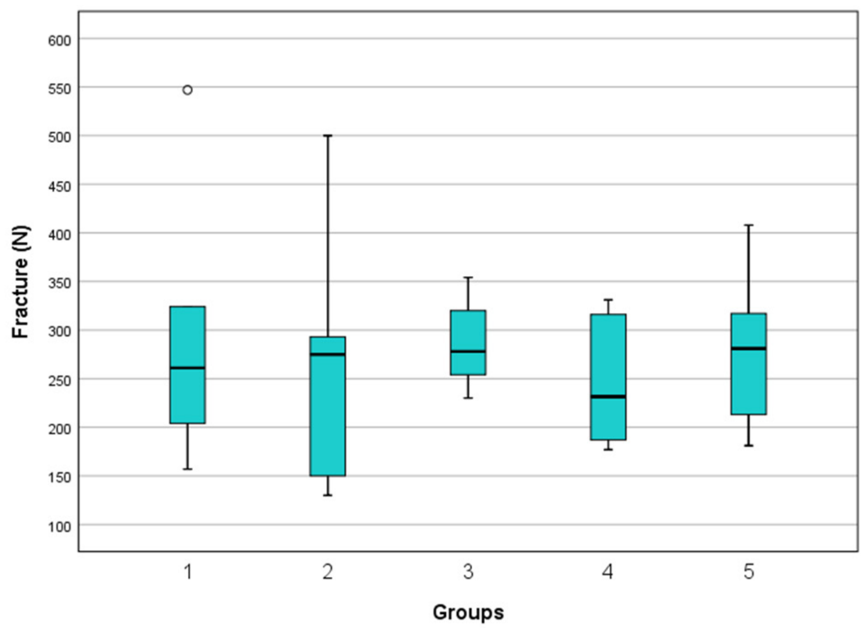

Figure 6. Boxplots of the fracture resistance (N) among groups.

statistical analysis revealed that the observed differences among the five groups were not significant (p-value = 0.891).

Discussion

The study's findings indicated that there was no significant variation in fracture resistance or failure mode among the groups tested, which confirms the null hypothesis. Group 1 had the highest mean fracture resistance value at 292.33 ± 137.14 N, while group 4 had the lowest at 245.67 ± 64.48 N. Although group 5 had the greatest median, statistical analysis demonstrated that the differences among the five groups were not statistically significant (p-value = 0.891).

The study's outcomes revealed that Group 1 had the highest average fracture resistance, while Group 4 had the lowest. However, the difference in resistance among the five groups was not significant. This finding contradicts the view that the fracture resistance and fracture mode of rehabilitated roots with PEKK posts is directly related to the post's diameter [9]. Furthermore, it was noted that all groups experienced fracture in the same manner, where the fracture occurred at the coronal level of the PEKK post, but did not result in any fracture at the level of the tooth. Hence, it can be concluded from these findings that clinicians can safely turn the diameter of the PEKK post and core as thin as 0.70mm till 1.70mm depending on the clinical requirement and the root diameter without the risk of fracturing the root, irrespective of the post's diameter. This is because none of the PEKK posts caused any fracture in the root, and this observation was visually and radiographically confirmed across all groups.

The fracture resistance of the PEKK posts was considerably high, possibly because of the similar elastic modulus of the PEKK post and dentin. Under the loading force, they flex together, making the dentin-like behavior of the posts helpful in distributing stress and yielding high fracture strength values [12]. Furthermore, this polymer has high biomechanical properties and it is utilized lately in dentistry in prosthetic dentistry for; fixed restorations which are free of metal, endocrowns, fixed implant-supported prosthesis, fixed resin bonded prosthesis, removable prosthesis, implant-retained overdenture, for producing implant, healing abutment, occlusal guards, and implant abutment [13-22].

To ensure consistency, teeth with similar sizes and shapes were chosen from a narrow age range and subjected to International Standardization Organization guidelines. To enhance the fracture resistance of reinforced teeth, all posts used in this study were bonded using resin cement, which is recommended for post cementation. This type of cement increases the adhesion capacity of the post and exhibits improved toughness and durability, as well as low solubility and minimal microfiltration, when compared to traditional cement [9]. RACE EVO (FKG DENTAIRE) 4% Taper were primarily selected to reduce the aggressiveness of hand instruments within the root canal, to maintain normal root canal anatomy, and to standardize root canal instrumentation. RACE EVO (FKG DENTAIRE) 4% Taper remove a conservative amount of root dentin and shape the root canals with irrigation with 5.25% sodium hypochlorite [9].

When evaluating the fracture resistance of teeth, the angle at which the loading force is applied to the specimen can have a significant impact. Fracture resistance improves when the loading force is oriented more parallel to the long axis of the specimen. To simulate clinical lateral occlusion in the anterior region, the loading force in this study was applied at a palatal angle of 45° to the horizontal [35].

Ferrario et al. found that healthy young adults had a maximum biting force of 75 to 190 N in the anterior region [23]. According to other reports, adults exhibit maximum bite forces ranging from 250 to 400 N in the molar area, patients with bruxism the force peaks can be as high as 1000 N, and forces ranging from 140 to 170 N in the anterior area [24, 25]. Group 3 had the lowest fracture resistance value, which was 230 N for PEKK posts, surpassing the maximum incisal biting forces. These results were consistent with a study done in cooperation with the University of Genoa, where the values reached by veneered Pekkton was 211.6 N and Pekkton was 194.4 N [26]. Additionally, there was post displacement observed across all of the tested groups. This could be due to the post's low elastic modulus resulting in higher bending under loading stresses, which leads to debonding of the cement and complete displacement of the PEKK posts [27, 28]. However, none of the tested groups showed any post or root fracture, which may be attributed to the close similarity between the accepted range of elastic modulus of dentin (13-16 GPa) and the PEKK post (3.7-4.0 GPa) [29, 30].

Moreover, in a study by Menini M. et al, the results have shown that the traditional materials such as zirconia, glass-ceramics, or gold alloy conveyed greater stresses to the simulated peri-implant bone. Conversely, the utilization of Pekkton® ivory, whether as a framework material or in full anatomical form, resulted in a substantial reduction of occlusal stress by up to 69.71% compared to zirconia [31].

In an article by Senturk et al, stress distribution was observed at the coronal third of the root on the facial surface in all studied models, with a value of 49.87 MPa for PEKK posts. The author also stated that the elastic modulus of PEKK close to dentin resulted in a slight decrease in stress concentration [32].

Furthermore, they can be easily and swiftly removed from the root canals for retrievability. Moreover, the PEKK posts exhibit adhesive and micromechanical bonding properties with the resin cement, dentin, and composite core, resulting in a natural-looking hue that enhances aesthetics without significantly sacrificing the material strength. This is an excellent result, in contrast to other post systems that may crack or fracture the root surface. This is elaborated in a study conducted by Haupt et al in 2021, where they compared the dentinal microcrack formation according to different post removal techniques [33]. Moreover, in a study conducted by Saleh et al in 2023, they compared the fracture resistance among metal cast posts, zirconia posts, fiberposts, and PEKK posts. According to their findings, they concluded that PEKK posts have the highest percentage of repairable fractures, owing to its retrievability [34].

In addition, the availability of fiber posts with appropriate shapes for flared canals is limited. The use of a standard geometry glass fiber post may result in excess space within the flared root canal, requiring a bulk of luting cement to fill the void. This can create a vulnerable area that could impact the long-term outlook [35].

It is also crucial to highlight the effect of increasing diameter on bond strength, that may change the load distribution. This is demonstrated in a study by Kole and Ergun et al, that as the diameter of the post increases, the cement's surface area increases, and hence the bond strength. This is observed in the study, where the bond strength of PEKK posts decreased from cervical to apical sections, on cyclic loading. The author also emphasized that PEKK posts demonstrated higher bond strength than fiber posts, since they observed a wide cement gap in fiber posts, while PEKK posts demonstrated homogeneous distribution of the cement in sem and light microscopy analyses [36].

Moreover, this anatomically shaped post reduces the amount of luting cement required and provides a better fit to the canal wall. Due to its elastic modulus being similar to dentin, PEKK facilitates a more uniform distribution of stress between the PEKK post and dentin surface, resembling that of an intact tooth [37]. Anatomical PEKK posts resulted in better biomechanical properties compared with other methods, regardless of the diameter.

Overall, considering the findings above, PEKK posts seem to have the best prognosis on the biomechanics on endodontically treated teeth, durability, esthetics, respect to root canal morphology, and retrievability.

In prospective studies, it may be interesting to investigate the possible relation effect of length to diameter ratio on the flexural strength of PEKK material for further study.

Conclusion

Within the limitations of the current study, obtaining human teeth from different sources and their mechanical testing was quite a hassle. Obtaining intact teeth free from any developmental anomalies or damage caused by the extraction process posed significant challenges. Additionally, preparing the teeth without causing thermal or mechanical damage further proved to be difficult. Individual differences related to age, pulp size, the time elapsed post-extraction further limited the study's scope. Also another limitation is that no aging was done in this study. Furthermore, this pilot study has a small sample size. Consequently, further studies will be necessary to substantiate these findings.

The use of milled PEKK intraradicular post and core in restoring endodontically treated teeth in the esthetic zone seems to be effective and promising in the improvement of fracture resistance, and increase the favorable mode of failure. Moreover, the dentist will be able to thicken the diameter of the post as much as possible with no risk of root fracture, as specified by the guidelines of this research.

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