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Comparison of fracture strengths of post-core systems produced using traditional methods and CAD/CAM in endodontically treated teeth

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Abstract

Aim: The purpose of this study was to compare the fracture strengths of post systems used with CAD/CAM and traditional methods.

Methodology: A total of 30 maxillary central teeth were used in the study. After the root lengths were standardized to be 10 mm, post sockets were prepared in the root canals. A total of 30 teeth were randomly divided into three groups (n=10). The post sockets were measured with silicone and sent to the laboratory. Samples were prepared after laboratory procedures. PEEK posts, fiber posts, and zirconia posts were cemented to the post sockets with resin cement. The test samples were kept at room temperature for 24 hours and then subjected to thermal cycling. After thermal cycling, force was applied to the test samples at a speed of 1 mm/min until the sample fractured. Statistical analysis was performed using one-way ANOVA ($p<0.05$) in SPSS.

Results: The statistical analysis revealed a significant difference in mean fracture resistance among the groups ($p<0.05$). The highest mean fracture strength value in the tested groups was observed in the fiber post group (410.9 ± 106.2 N). The lowest mean was observed in the PEEK post group (215.1 ± 77.7).

Conclusion: All groups of PEEK, glass fiber, and zirconium oxide post-cores showed sufficient fracture strength when compared with the mean of the maximum forces that can be applied to the teeth in the anterior region.

Keywords: PEEK, post-core, fracture strength, fiber post, zirconia post, CAD/CAM

Introduction

Due to caries, tooth fractures, or previous extensive restorations, the coronal tooth tissue of endodontically treated teeth is often weak. Faulty restorative applications can cause failures, particularly vertical root fractures, which may result in tooth loss. In endodontically treated teeth, a post is often needed to eliminate tissue loss and ensure retention of the final restoration. Maintaining retention during post-application significantly affects the success of the restoration (1, 2).

Restorative materials used for endodontically treated teeth should exhibit mechanical properties similar to those of dentin. In addition, these materials should be able to bond to the tooth tissue and should be biocompatible to obtain a good clinical result in the oral environment (3, 4)

In clinical practice, depending on the impression materials used or the plaster's detailing quality during model fabrication, the model may not fully reflect the oral environment, thereby reducing the ideal fit of the restoration (5). The ability of CAD/CAM systems to scan the measured data is an advantage for restoration. The measurements are digitally scanned, and post-core production is required using materials that are more compatible with the tooth root and that create less stress. For this purpose, zirconia and PEEK (polyetheretherketone) are used in CAD/CAM systems. In addition, prefabricated fiber posts are used in routine clinical practice (6, 7)

PEEK has a lower modulus of elasticity (4 GPa) compared to dentin, but it is known to have high compressive strength. In addition to all these features and biocompatibility, a wide range of production and processing capabilities, including milling and pressing, have made PEEK an attractive dental material for the production of personalized post-core systems. It is an alternative material to fiber- and zirconia-based posts, which are widely used clinically (8, 9).

Zirconium-based all-ceramic posts are biocompatible, radiopaque, and have good physical properties. Their major disadvantages are lower fracture resistance than metal posts and weaker bonding to the tooth and core material. Another disadvantage is that when they break, the part remaining in the root is quite difficult to remove (10-12).

Fiber posts have an elastic modulus comparable to that of dentin. Fibers distribute stresses over larger surface areas, thereby significantly increasing load resistance. Thus, when the material begins to exhibit microfractures, the loading threshold increases significantly. The distribution of stresses and the increase in fatigue resistance are superior features of fiber-reinforced materials (9-11). In biomechanical analyses in dentistry, destructive mechanical tests used to determine fracture resistance are important ways to analyze the biomechanical behavior of the materials being evaluated.

In clinical studies, it has always been a matter of debate which of the glass fiber and zirconia post systems is more routinely applicable, but these posts have been shown to have the same fracture resistance (4, 16). Since PEEK is a current material, we planned to compare it with the other two post systems. According to our hypothesis, PEEK post-core groups present more repairable fractures than the other post-core groups. In this study, fracture resistance under load was compared using different post systems.

The aim of this study was to compare the fracture strengths of post systems used with CAD/CAM and traditional methods.

Materials and Methods

This study received approval from the Harran University Clinical Research Ethics Committee for this study (decision no. 22.16.25, August 22, 2022). The sample size was calculated using G*Power 3.1 software (Heinrich Heine University, Düsseldorf, Germany), with 80% power (0.8). The prefabricated posts and CAD/CAM materials used in our study are shown in Table 1.

The sample size was determined to be 10 teeth per group, based on a prior sample size calculation. Teeth were randomly assigned to three experimental groups, each containing 10 specimens, and cemented with different luting agents. Maxillary central incisors extracted for periodontal reasons were selected. Inclusion criteria were human maxillary central incisors and periodontally involved central incisors, whereas exclusion criteria included teeth with developmental anomalies, calcifications, fractures, caries, or external cracks. To ensure standardization, 30 teeth with a root length of 10 mm were included in the study. The teeth were disinfected with 0.5% sodium hypochlorite (NaOCl) solution and stored in dark-colored, covered glass containers filled with distilled water. Tissue residues on the tooth surfaces were removed using a periodontal instrument. For root canal preparation, the working length was established 1 mm shorter than the root canal length, and the ProTaper Next (Dentsply, Tulsa Dental, Tulsa, England) nickel-titanium rotary instrument system was utilized with a crown-down preparation method. 5.25% NaOCl was used as an irrigation solution. 5.25% NaOCl served as the irrigation solution, followed by irrigation with physiological serum and drying with paper points (Dentsply, Tulsa Dental, Tulsa, OK, USA). Following root canal preparation, the canals were obturated with resin-based AH Plus Jet root canal sealer (Dentsply DeTrey, Konstanz, Germany) and ProTaper Next X3 gutta-percha (Dentsply DeTrey, Konstanz, Germany) using the single cone technique. Canal orifices were subsequently closed with temporary filling material (Cavit G, 3M ESPE, Seefeld, Germany).

After shaping, 30 teeth with root canal fillings were randomly divided into three groups: a PEEK group, a zirconia group, and a conventional fiber post group. 9 mm stoppers were placed on the bur of the prefabricated

Snowpost 1.2. The post space was prepared using this bur until the working size was reached. Burs were renewed every 5 teeth. After the post space was washed and dried, 35% phosphoric acid (Ultradent Products, Inc., South Jordan, UT, USA) was applied to the root dentin for 15 seconds and washed with water for 1 minute and dried.

With the help of metal impression posts created in sizes suitable for the existing post spaces and impression carriers obtained by cutting dental syringe tips, the negative of the post space was obtained using C-Type silicone (Zetaplus, Zhermack, Badia Polesine, Italy) (Fig. 1). The obtained impressions were scanned, and zirconium oxide (Upcera CT Color, Shenzhen Upcera Dental Co., Shenzhen, Guangdong, China) post-cores were obtained with the CAD/CAM technique.

For the production of zirconia posts, PEEK (Juvora, Juvora Ldt, Thornton Cleveleys, Lancashire, England) post-cores were obtained for each model by scanning the negative measurements using CAD/CAM. All groups were cemented using RelyX Unicem. Teeth were embedded in transparent orthodontic acrylic resin (Imicryl Inc., Konya, Türkiye) parallel to their long axes. Following this procedure, the samples were placed in a universal testing machine (Instron Corp., Canton, MA, USA) for fracture testing. The round tip of the testing machine, which had a diameter of 6 mm, was adjusted to be perpendicular to the occlusal plane of each tooth. The device was operated at a piston head speed of 1 mm/min, and the values at the moment the teeth were fractured were recorded in newtons.

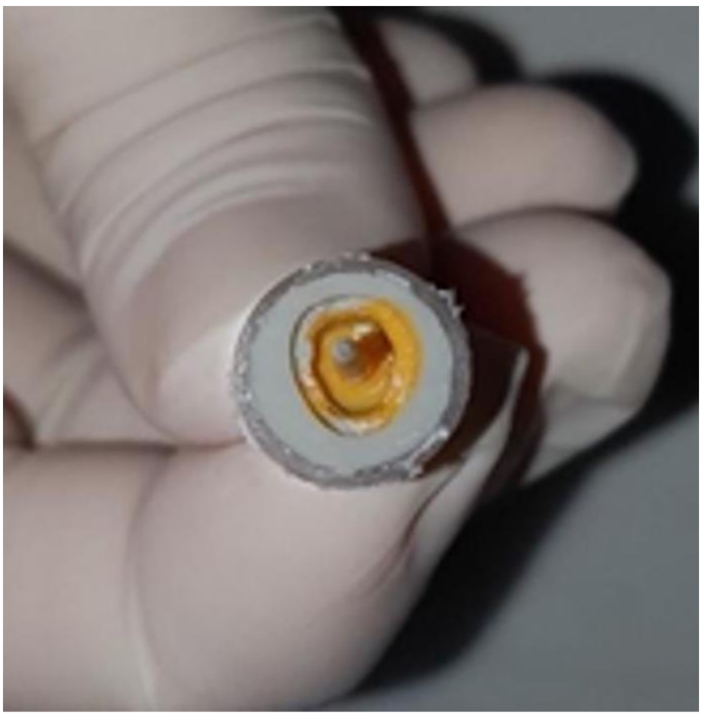

Figure 2. Measurement of post spaces.

Statistical analysis

Analyses were performed using IBM SPSS Statistics version 26.0 (IBM Inc., Armonk, NY, USA). Statistical significance was determined at $p<0.05$.

Descriptive statistics for the fracture strength evaluation of the groups in which three different post materials were created were shown as means, standard deviations, minimum values, and maximum values. A one-way ANOVA was conducted to assess whether there were significant differences in fracture strength among the groups; if a significant difference was detected, an LSD (Least Significant Difference) post hoc test was used to identify specific group comparisons.

Results

The statistical analysis revealed a significant difference in mean fracture resistance among the groups ($p<0.05$). The highest average breaking strength value in the tested groups was observed in the fiber post group (410.9 ± 106.2 N). The lowest average was observed in the PEEK post group (215.1 ± 77.7) (Fig. 2, Table 2).

Table 1. Product manufacturer and materials used.

Material	Product Name	Manufacturer
PEEK	Juvora Dental Disc	Juvora Ltd., Thornton-Cleveleys, Lancashire, UK
ZIRCONIA POST	Upcera CT Color	Shenzhen Upcera Dental Co., Ltd., Shenzhen, China
GLASS FIBER POST	Snowpost	Abrasive Technology, LLC, Lewis Center, OH, USA
DUAL-CURE RESIN CEMENT	RelyX Unicem	3M Deutschland GmbH, Seefeld, Germany
C-TYPE SILICONE	Zetaplus	Zhermack S.p.A., Badia Polesine, Italy
ACRYLIC RESIN	Orthodontic Acrylic	Imicryl Dental and Medical Industries, Konya, Türkiye

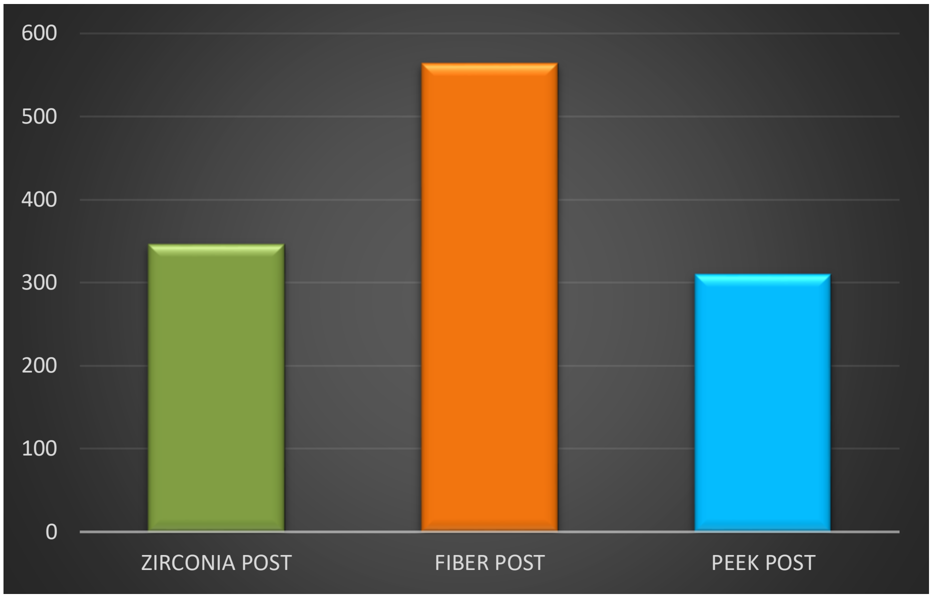

Figure 2. Average fracture strength values across materials.

Table 2. Descriptive statistics on fracture strengths by groups.

	N	Mean ± SD	Minimum	Maximum
ZIRCONIA POST	10	301±27.5	223.3	346.2
FIBER POST	10	410.9±106.2	184.6	564.2
PEEK POST	10	215.1±77.7	162.9	310.1

Discussion

This study aimed to evaluate the fracture resistance of post restorations made using different materials in endodontically treated teeth with excessive crown damage. To restore occlusion in teeth with excessive material loss, it is necessary to increase the retention of the post. For this purpose, fabricated and cast posts are used. Drilling during post space preparation can induce cracks and vertical fractures in the roots (2-4).

Today, numerous advanced systems and materials are utilized in post-core systems. However, an ideal system or material for biomechanics and aesthetics has not yet been discovered. Both positive and negative features of the materials significantly affect the success of the treatment and require that the system be applied with a delicate procedure. Further development of materials and techniques is expected to yield improved outcomes. Rapidly advancing technology and the superior properties of materials, particularly fiber posts, have increased their widespread use and suitability (5, 6, 13, 14, 18).

In this study, we compared PEEK, zirconia, and Snow posts. The Snow fiber post, a prefabricated post recommended for its elastic modulus that is close to that of dentin (15), was used in our study. However, CAD/CAM-produced PEEK and zircon posts were expected to exhibit the same predisposition, but according to the results, our hypothesis was rejected.

Zirconia posts are more prone to root fractures than fiber posts due to their very low flexibility, and they have disadvantages such as the zirconia post surface not showing a connection with the composite resin (11, 13, 17). A study by Akkayan et al. reported that while a small number of irreparable fracture types were observed in teeth restored with fiber-reinforced composite posts, this rate increased when zirconium ceramic posts were used, and all teeth restored with titanium posts were broken beyond repair (4). A meta-analysis of long-term clinical studies demonstrated higher success rates for fiber posts compared to other post systems. Root fractures in low elastic modulus fiber posts occurs in the cervical region of the tooth, which increases the possibility of reuse of the remaining tooth root. Most studies have shown that the main role of the post-core is to connect the crown and root as a whole and that the most important factor affecting root fracture is the amount of remaining tooth tissue (10, 11, 14). The results of our study are consistent with the findings of Akkayan et al.

The aim of this study was to evaluate the fracture strengths of PEEK and zirconia posts. Although PEEK is reported to have superior mechanical, chemical, thermal, and aesthetic properties, with low fracture risk and high compressive strength, in our study the highest average fracture strength was observed in the fiber post group (410.9 ± 106.2 N). Conversely, the lowest average fracture strength was observed in the PEEK post group (215.1 ± 77.7 N).

Özarslan et al. reported increased decementation and reduced fracture strength at lower forces in their study using a PEEK material, a fiber post, and a zirconia post (9). This is a parallel result with our study. In fact, although PEEK material shows low fracture strength, the fact that the fracture can be repaired highlights its use in the clinic. Fractures in other materials create fractures that are difficult to repair, and especially apex fractures cause tooth extraction (9-11).

Alqahtani concluded in a systematic study that PEEK post showed encouraging results with its excellent mechanical and bonding capacities and reported that it is an alternative to be used in clinical practice (14). In the studies conducted, an increase in retention was observed when surface treatments were applied to the PEEK posts (11-14, 19). We used resin cement in our study; because we did not perform surface treatment, the lowest result was likely for the PEEK post.

The use of PEEK as a post and core material suggests a lower risk of root fracture because its elastic modulus, similar to dentin, improves stress distribution in the root. Therefore, PEEK, along with a suitable surface treatment and bonding agent, can be a reliable option (19-21). However, in our study, we did not apply any surface treatment to the PEEK post. The differences in results may be due to surface treatments and bonding. Increasing the sample size and employing surface treatments, such as sandblasting and silane, might have affected the results.

PEEK has a lower elastic modulus than natural teeth and bone. Therefore, studies have shown that it distributes stresses more favorably compared to materials such as fiberglass and alloys (22, 23). In addition, studies have compared the mechanical properties and retention characteristics of PEEK posts with those of other materials; however, due to the lack of peer-reviewed systematic reviews, the general consensus regarding the performance of PEEK posts relative to other materials remains unclear (22, 23). As a result, although new materials excite the scientific world, a lot of work is needed. In this study, materials used in in vitro dental treatments are evaluated; however, the study is not registered for clinical trials.

Conclusion

The type of post affects the root fracture resistance of teeth with excessive substance loss. In our study, the highest fracture resistance was observed in the fiber post, while the lowest fracture resistance was seen in PEEK. Further in vitro, in vivo, and clinical follow-up studies are required to support the clinical use of PEEK.

Disclosures

Ethical Approval: Ethics committee approval was received for this study from the Harran University Clinical Research Ethics Committee, in accordance with the World Medical Association Declaration of Helsinki, with the approval number: 2022-22.16.25.

Peer-review: Externally peer-reviewed.

Author Contributions: Conception – Z.G.; Design – Z.G.; Supervision – Z.G.; Materials –Z.G.; Data Collection and/or Processing – Z.G.; Analysis and/or Interpretation – Z.G.; Literature Review – Z.G.; Writer –Z.G.; Critical Review – Z.G.

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References

1. Topdaği B, Bayindir F. Investigation of fracture strength of current post materials (PEEK, fiber, cast metal) in different ferrule conditions. Open J Stomatol. 2024;14(3):143-157. https://doi.org/10.4236/ojst.2024.143013
2. Pourkhalili H, Maleki D. Fracture resistance of polyetheretherketone, Ni-Cr and glass post-core systems. J Dent Res Dent Clin Dent Prospects. 2022;16(1):11-15. https://doi.org/10.34172/joddd.2022.003
3. Owen TA, Barber M. Direct or indirect post crowns to restore compromised teeth: a review of the literature. Br Dent J. 2018;224(6):413-418. https://doi.org/10.1038/sj.bdj.2018.218
4. Akkayan B, Gülmez T. Resistance to fracture of endodontically treated teeth restored with different post systems. J Prosthet Dent. 2002;87(4):431-437. https://doi.org/10.1067/mpr.2002.123227

5. Zhou L, Wang Q. Comparison of fracture resistance between cast posts and fiber posts: a meta-analysis of literature. J Endod. 2013;39(1):11-15. https://doi.org/10.1016/j.joen.2012.09.026
6. Figueiredo FED, Martins-Filho PRS, Faria-e-Silva AL. Do metal post-retained restorations result in more root fractures than fiber post-retained restorations? A systematic review and meta-analysis. J Endod. 2015;41(3):309-316. https://doi.org/10.1016/j.joen.2014.10.006
7. Shekar RI, Kumar MNS, Rao PMD, et al. Studies on the composites produced from co-weaved poly ether ether ketone and glass fiber fabric. J Compos Mater. 2011;45(6):741-749. https://doi.org/10.1177/0021998310378906
8. Vinothkumar TS, Kandaswamy D, Chanana P. CAD/CAM fabricated single-unit all-ceramic post-core-crown restoration. J Conserv Dent. 2011;14(1):86-89. https://doi.org/10.4103/0972-0707.80730
9. Özarslan M, Büyükkaplan UŞ, Özarslan MM. Comparison of the fracture strength of endodontically treated teeth restored with polyether ether ketone, zirconia and glass-fibre post-core systems. Int J Clin Pract. 2021;75(9):e14440. https://doi.org/10.1111/ijcp.14440
10. Yang A, Lamichhane A, Xu C. Remaining coronal dentin and risk of fiber-reinforced composite post-core restoration failure: a meta-analysis. Int J Prosthodont. 2015;28(3):258-264. https://doi.org/10.11607/ijp.4157
11. Jurukovska-Shotarovska V, Kapusevska B. Comparative analysis of the mechanical properties between the fiber-reinforced composite and zirconium posts. Prilozi. 2015;36(2):138-149. https://doi.org/10.1515/prilozi-2015-0089
12. Sultan SE, Korsiel AM, Kamel MS, Etman WM. Effect of different surface treatments of luted fiber posts on push out bond strength to root dentin. Tanta Dent J. 2013;10(3):116-122. https://doi.org/10.1016/j.tdj.2013.11.003
13. Değirmenci BÜ, Rasool FW. Evaluating the masking ability of CAD/CAM hybrid ceramics with different thicknesses. Int Dent Res. 2021;11(2):114-120. https://doi.org/10.5577/intdentres.2021.vol11.no2.9
14. Alqahtani NM. The application of polyether ether ketone as post and core: a systematic review. Ann Med Health Sci Res. 2021;11(5):1426-1431.
15. Teixeira EC, Teixeira FB, Piasick JR, Thompson JY. An in vitro assessment of prefabricated fiber post systems. J Am Dent Assoc. 2006;137(7):1006-1012. https://doi.org/10.14219/jada.archive.2006.0323
16. Stricker EJ, Göhring TN. Influence of different posts and cores on marginal adaptation, fracture resistance, and fracture mode of composite resin crowns on human mandibular premolars: an in vitro study. J Dent. 2006;34(5):326-335. https://doi.org/10.1016/j.jdent.2005.07.007
17. Polat ZS, Tacir IH, Eskimez S, Celik MY. Retentive force of three fiber-reinforced resin composite posts and a zirconia post cemented with two adhesive luting agents: in vitro study. Dent Mater J. 2007;26(5):672-676. https://doi.org/10.4012/dmj.26.672
18. Beh YH, Halim MS, Ariffin Z. The load capacity of maxillary central incisor with simulated flared root canal restored with different fiber-reinforced composite post and cementation protocols. PeerJ. 2023;11:e16469. https://doi.org/10.7717/peerj.16469
19. Teixeira K, Duque T, Maia H, Gonçalves T. Fracture resistance and failure mode of custom-made post-and-cores of polyetheretherketone and nano-ceramic composite. Oper Dent. 2020;45(5):506-515. https://doi.org/10.2341/19-080-L
20. Lee KS, Shin JH, Kim JE, et al. Biomechanical evaluation of a tooth restored with high performance polymer PEKK post-core system: a 3D finite element analysis. Biomed Res Int. 2017;2017:1373127. https://doi.org/10.1155/2017/1373127
21. Benli M, Eker Gümüş B, Kahraman Y, Huck O, Özcan M. Surface characterization and bonding properties of milled polyetheretherketone dental posts. Odontology. 2020;108(4):596-606. https://doi.org/10.1007/s10266-020-00484-1
22. Saisho H, Marcolina G, Perucelli F, et al. Fracture strength, pull-out bond strength, and volume of luting agent of tooth-colored CAD-CAM post-and-cores. J Prosthet Dent. 2023;129(4):599-606. https://doi.org/10.1016/j.prosdent.2022.06.012
23. Najeeb S, Zafar MS, Khurshid Z, Siddiqui F. Applications of polyetheretherketone (PEEK) in oral implantology and prosthodontics. J Prosthodont Res. 2016;60(1):12-19. https://doi.org/10.1016/j.jpor.2015.10.001