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Evaluation of stress distribution in an endodontically treated tooth restored with two different post and core systems in a maxillary central incisor: A finite element analysis study

D S S Vishnu Pavan[1,*], Sampathi Naga Lakshmi Reddy[2], Upendra Natha Reddy[3], Neshaneni Sathish Kumar[4], Medum Shabharish Shyam Kumar[5], Ch Meher Meenakshi[5]

[1]Postgraduate Student, Department of Conservative Dentistry and Endodontics, G Pulla Reddy Dental College and Hospital, Kurnool, Andhra Pradesh, India.
[2]Professor and Head, Department of Conservative Dentistry and Endodontics, G Pulla Reddy Dental College and Hospital, Kurnool, Andhra Pradesh, India.
[3]Professor, Department of Conservative Dentistry and Endodontics, G Pulla Reddy Dental College and Hospital, Kurnool, Andhra Pradesh, India.
[4]Reader, Department of Conservative Dentistry and Endodontics, G Pulla Reddy Dental College and Hospital, Kurnool, Andhra Pradesh, India.
[5]Senior Lecturer, Department of Conservative Dentistry and Endodontics, G Pulla Reddy Dental College and Hospital, Kurnool, Andhra Pradesh, India.

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*Correspondence

D S S Vishnu Pavan
Postgraduate Resident,
Department of Conservative Dentistry
and Endodontics
G Pulla Reddy Dental College and Hospital,
Kurnool, Andhra Pradesh, India.
E-mail: vishnud2831@gmail.com
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Abstract

Background: An endodontic post plays a crucial role in stabilizing and supporting a core restoration when insufficient coronal dentin remains after root canal treatment. It is inserted into the prepared root canal, strengthening the restoration and enabling it to endure chewing forces, thereby helping to preserve the tooth structure and overall durability of the restoration.
Aim: To evaluate the biomechanical behaviour and long-term safety of high-performance polymer PEEK as an intra-radicular dental post-core material through comparative finite element analysis (FEA) with other traditional (Nickel-Chromium) post-core material.
Materials and methods: CBCT scanning of a maxillary central incisor and its supporting structures was used to construct a two-3D solid model of endodontically treated teeth for finite element analysis (FEA). PEEK has a lower elastic modulus than root dentin and showed comparably more favourable stress distribution and high failure resistance than conventional post-core material. Two materials, Nickel-Chromium and PEEK, with the same crown design, were simulated to compare traditionally used post-core materials and evaluate their post-core properties. A 3D model of the maxillary central incisor area, including restorative components, was created. The masticatory load of 100 N was simulated at a 5 mm distance from the incisal edge and applied at a 45˚ angle to the long axis of the tooth.
Results: PEEK and metal post models demonstrated similar patterns and values of maximum equivalent stresses in the overall components of the model, except for the post and crown. In the apex region of the PEEK post-core case, the values of stresses were lower than those of metal posts.
Conclusion: PEEK post-core, with a lower elastic modulus than dentine, exhibited a favourable stress distribution profile at the intraradicular surface, indicating a lower possibility of root fracture than conventional post-core materials.
Keywords: Polyether ether ketone (PEEK), Nickel-Chromium, Finite element analysis, Post and core.

1. Introduction

Endodontically treated teeth exhibit the major loss of coronal dental tissues due to caries, fractures, and access cavity preparation procedures [1]. A successful restoration of endodontically treated teeth significantly affects their survival. The remaining coronal tooth structure, the tooth's position in the arch, and the esthetic requirements will determine the type of restoration indicated, whether it is restored directly or reinforced with a post, core, and crown [2,3]. Clinicians use posts and core foundations to support the final restorations of grossly destructed teeth [4]. Posts are usually classified into two major categories: custom-made and prefabricated posts [5]. Traditionally, custom-made posts were fabricated in dental labs from cast metals such as gold, palladium, silver, and base metal alloys [6].

Recently, however, they have increasingly made using Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) technology from materials like zirconia, glass-fibre reinforced composite, Nickel-chrome, hybrid ceramics, nano-ceramics, and Polyetheretherketone (PEEK) [7]. Custom-made posts adapt well to the root canal, have good mechanical proprieties, and have a long history of success in restoring endodontically treated teeth. Due to their high modulus of elasticity, these materials can withstand high occlusal forces before deformation occurs [8]. Prefabricated posts have gained popularity recently because they offer satisfactory results with minimal preparatory work, saving both time and cost [8].

However, due to a high elastic modulus difference between metal alloys and dentine, an excessive functional stress concentration may occur around the post, resulting in catastrophic root fracture [9]. Therefore, various post-core materials have been investigated to achieve long-term safety. Previous studies reported that a more favourable stress distribution is achieved using a post with a lower elastic modulus [10]. However, since fibreglass posts are generally supplied as ready-made products, they are limited in terms of their conformity to the shape of the root canal. In addition, although fibreglass posts have lower elastic moduli (from 45.7 to 53.8 GPa) than those of metal alloy posts (110.0 GPa for titanium and 95.0 GPa for gold), these are still approximately three times the elastic modulus of dentin (18.6 GPa) [11]. Employing post materials with an elastic modulus that is lower than that of dentin, like PEEK (Polyetheretherketone), promotes a more even distribution of stress across the dentin. This results in a failure type that is repairable at the neck of the tooth when a fracture occurs under excessive load [12].

PEEK is a tooth-coloured synthetic thermoplastic polymer, which exhibits suitable mechanical and shock-absorbing properties. Its ability to bond with both dentin and resin cement makes it an ideal material for use as a post. Using an adhesive luting cement for post retention, instead of threading, helps reduce the stress placed on the dentin [13,14]. PEEK is one of the organic thermoplastic polymers in the PolyArylEtherKetone (PAEK) family, best known as a high-performance polymer family, and mainly serves as an implantation material due its features and good biocompatibility in the medical field. It has been recognized as an adequate alternative biocompatible material for long-term proven titanium in orthopaedic applications. In dentistry, the main usage of the PEEK family has increasingly been as temporary implant abutments. In addition, it is used as dental clasps and frameworks for removable dental partial prostheses [15,16].

Advancements in dental materials and CAD/CAM technology enable clinicians to fabricate less time-consuming, highly accurate esthetic restorations. Posts and cores were not an exception as CAD/CAM technology permits the fabrication of custom-made PEEK posts and cores which can be used with full ceramic crowns thus overcoming the limitations of metal cast posts and cores [17,18].

Photoelastic stress analysis was also used to evaluate stresses responsible for the failure of a structure. The model needs to be made with similar conditions to the actual structure in terms of its geometry, support system, and the direction and strength of applied forces [19]. The distribution of internal stresses in the model should also be similar to those existing in the actual structure, regardless of the material. The calculations required to separate the principal stress values at a general interior point are very complicated. For precise stress analysis in large components, expensive equipment is needed. Also, 3D photoelasticity experiments are very time-consuming and tedious [20].

Fortunately, with rapid improvements in computer technology, finite element analysis (FEA) enables the user to accurately simulate a complex design like a post-crown endodontic restoration system and the natural condition of the oral cavity by entering various environmental parameters and tissue properties, overcoming the ethical issues and difficulties regarding medical studies [21].

The main objective of this study was to evaluate the biomechanical behaviour and long-term safety of high-performance polymer PEEK as an intra-radicular dental post-core material through comparative finite element analysis (FEA) with other traditional (Nickel-Chromium) post-core material.

2. Materials and methods

In this research, two types of custom-made posts and cores, PEEK and Nickel-Chrome, along with Zirconia full-coverage restorations, were utilized. The resin cement (Panavia F2.0, Kuraray, Japan) was employed for the bonding of the posts and full-coverage restorations.

2.1 Specimen preparation

A cone-beam computed tomography (CBCT) image of the right maxillary central incisor region was captured by a CBCT imaging machine (VGI Evo, Italy). The CBCT images were imported into the program MIMICS and materialized for segmentation. After segmentation, the polygonal model was saved in stereolithographic (STL) format and transferred to a reverse engineering program. The computer-aided three-dimensional interactive application (Hypermesh 19) was used for the generation of a solid model (Figure 1).

Two 3D Finite Element (FE) models of endodontically treated maxillary central incisor with two different posts & cores and the same full coverage restoration were designed for the analysis of stress distribution induced by applying the loads by using the ANSYS 17.0 software program, USA. The size and shape of the tooth were consistent with those of the anatomical atlas. The crown was 10.5 mm in length, with a medial distal width of 8.5 mm and a root length of 13 mm (the tooth was 23.5 mm long). A 0.2 mm thick periodontium was modelled around the root of the tooth. After creating the basic tooth model, an apical size of 40 and taper of 6% of the endodontic instruments and gutta-percha filling were simulated. Simulation of post space was done to a depth of 8 mm from the CEJ, leaving a minimum apical seal of 4–5 mm of gutta-percha in the canal space after post preparation and transversal tooth section 2 mm above the CEJ (ferrule effect) was made and the diameter of posts was 1.5 mm.

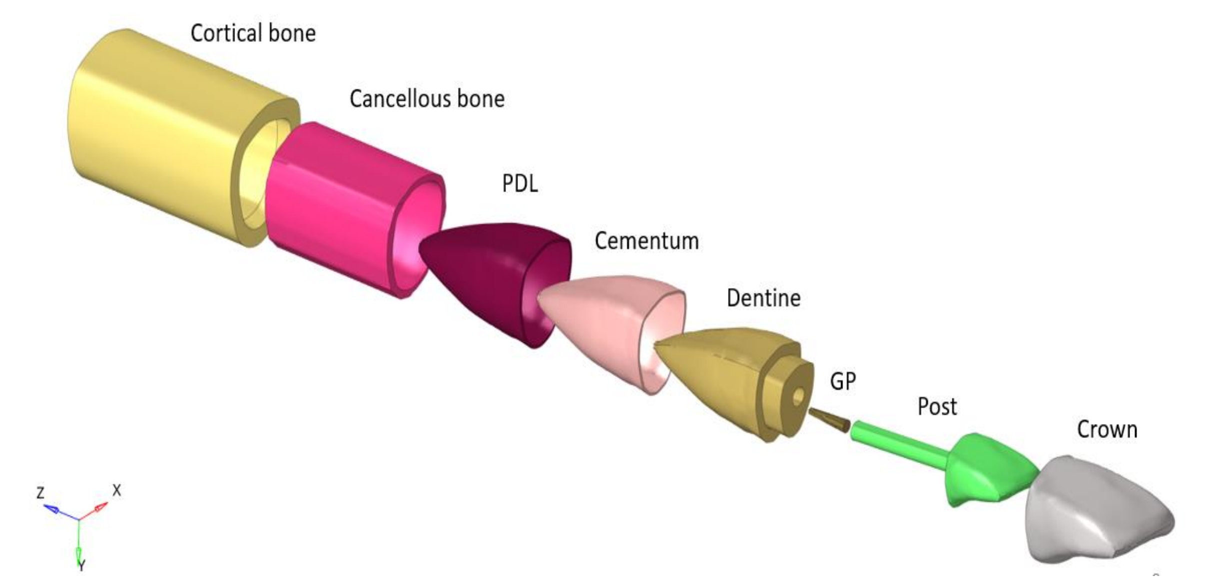

Figure 1. Different Components of constructed geometry models

Tooth Preparation was modelled according to the dimensions of the all-ceramic crown preparation for the full coronal coverage. Tooth reduction was modelled as 2 mm circumferentially and 2 mm incisally. The shoulder was kept as a finish line. The all-ceramic crown was modelled to fit the abutment. The all-ceramic crowns simulated in this study were Zirconia. All posts and crowns were cemented with Panavia F2.0 (Kuraray, Japan) with 0.1 mm thickness.

2.2 FE analysis

The 3D modelling of the maxillary central incisor region, along with restorative components, was done using the software, HyperMesh 19. The FE Models were obtained by importing the solid models into ANSYS17.0 FEM software, USA for stress analysis. All the materials were considered isotropic, homogeneous, and linearly elastic; these data were imported into the software program, together with the elastic modulus and Poisson's ratio values (Table 1). The models were then loaded with normal masticatory loads of 100 N at a distance of 5mm from the incisal edge, at an angle of 45 to the longitudinal axis of the tooth in coronal-apical and palatal-buccal directions (Figure 2). Meshing was conducted using quadratic tetrahedral elements, resulting in a total of 38189 nodes and 216854 elements in the study (Figure 3).

Table 1. Elastic modulus and Poisson's ratio of materials used in the current study

Materials	Elastic Modulus (GPa)	Poisson's Ratio
Cortical bone	13.7	0.3
Trabecular bone	1.37	0.3
Periodontal ligament	0.0689	0.45
Dentin	18.6	0.31
GUtta-percha	0.14	0.45
Zirconia	209.3	0.32
Resin cement	18.6	0.28
Nickel-Chromium alloy	205	0.33
PEEK	4.1	0.4

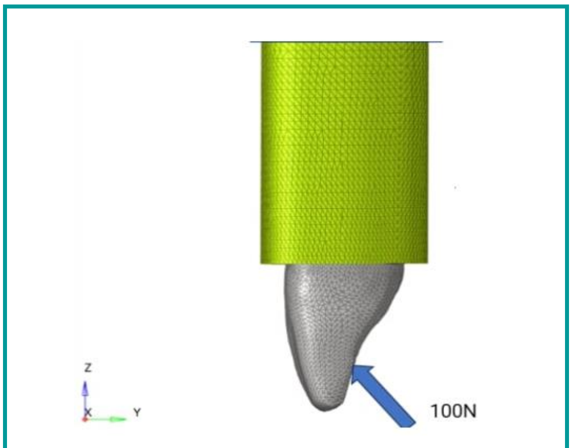

Figure 2. Force direction

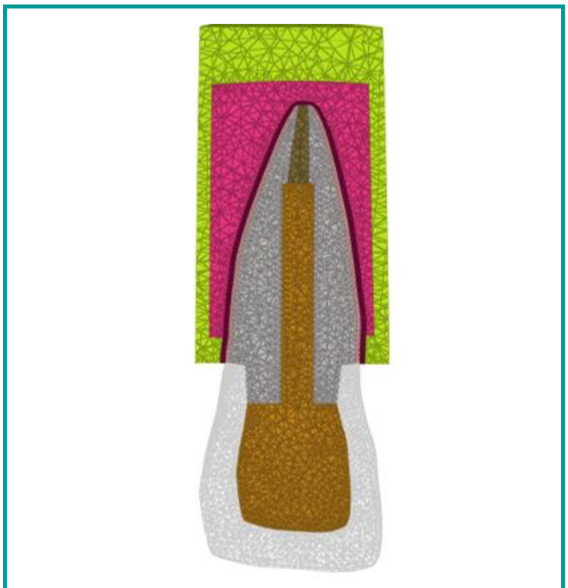

Figure 3. 3D Finite element meshing

Von Mises (Vm) stresses generated at the post and core assembly, coronal & radicular dentin were numerically recorded, colour-coded, and compared amongst the various models.

Model 1: Finite element analysis (FEM) of endodontically treated maxillary central incisors with Nickel-chrome post & core.

Model 2: Finite element analysis (FEM) of endodontically treated maxillary central incisors with PEEK post & core.

3. Results

The maximum von Mises equivalent stresses (MPa) of two FE models are presented in Table 2. The stress distribution in terms of colour contour patterns and the maximum value of VME stress of each component are shown in Figures 4 and 5. In Finite element analysis, Von Mises stress is a measure of the combined effect of different stress components. It's used to predict the yielding of materials under various loads. Peek and metal post models demonstrated similar patterns and values of maximum equivalent stresses in the overall components of the model, except for the post and crown.

On the other hand, the PEEK post-core model showed more stress concentration at the crown and the cervical area of the root. However, it showed significantly less stress concentration in the post-core component than in the metal post & core. In the metal post & core, the maximum stress values were located at the cervical region and 1/2 of the root. In the PEEK post-core case, the stress distribution and the maximum stress values were located at the core. In the apex region of the PEEK post-core case, the values of stresses were lower than those of metal posts. In addition, the stress in the cervical region of PEKK was dispersed in the mesio-distal direction.

Table 2. Comparative Evaluation of maximum von Mises equivalent stresses (MPa) within two FE models in this Study

von Mises Stress	PEEK Post	Ni-Cr Post
Crown	295	191
Post	32.72	118.62
Dentin	14.13	13.19
Cementum	13.92	13.01
PDL	3.08	3.03
Cement	2.12	1.39
Cancellous bone	2.075	2.064
Cortical bone	26.78	26.78

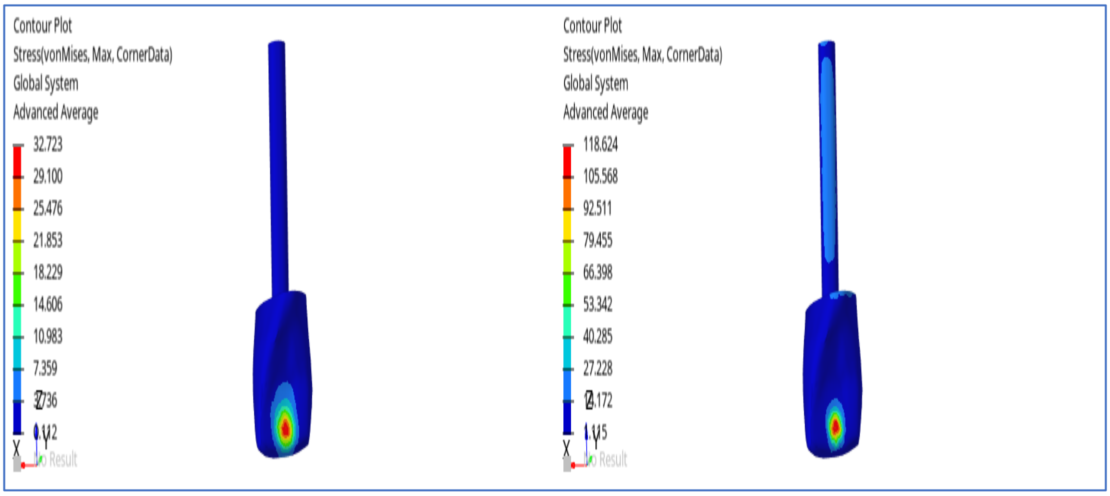

Figure 4. Stress distribution in PEEK and Ni-Cr post & core

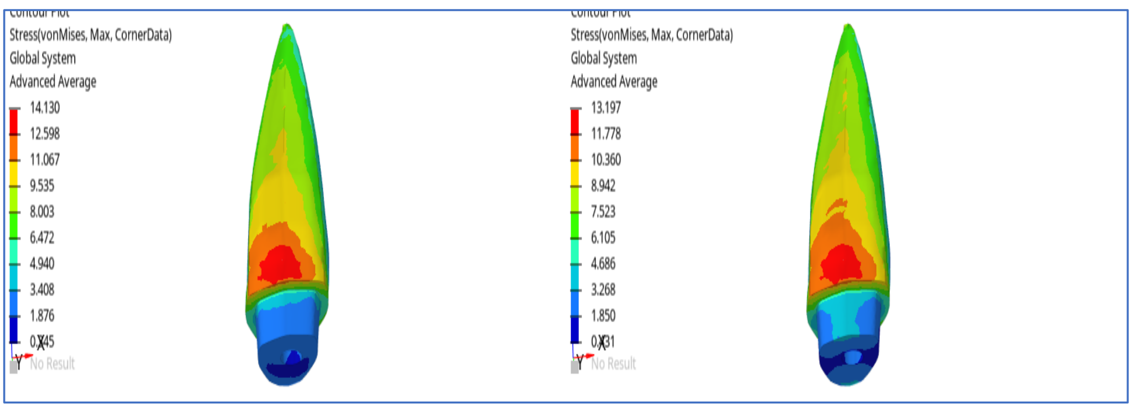

Figure 6. Stress distribution in Root dentin of PEEK and Ni-Cr post & core

4. Discussion

The risk of tooth fracture is an undesirable incident usually related to insufficient coronal tooth structure after endodontic treatment [22]. Rebuilding of the tooth structure by a post prior to crown restoration sometimes is mandatory to provide a stable and solid restoration of the tooth [23].

Analyzing stress distribution in post-core-restored endodontically treated teeth is challenging in vivo due to variations in mechanical and physical properties among different tooth tissues, which complicates the control of factors such as remaining tooth structure, load direction, and magnitude, as well as tooth position. In vitro tests also fall short as they cannot fully replicate the oral environment. To address these challenges, this study employed Finite Element Analysis (FEA) to simulate natural conditions within a complex design. Additionally, the Equivalent Von Mises (EVM) stress was utilized to assess stress distribution in critical areas, as it integrates both normal and shear stresses at specific points, which is crucial given the brittle nature of tooth tissues and the potential for failure [24,25]. So, in the current study, the models were studied as follows:
Model 1: An endodontically-treated maxillary central incisor with 2 mm ferrule and 1.5 mm diameter PEEK post & core. Model 2: An endodontically-treated maxillary central incisor with 2 mm ferrule and 1.5 mm diameter Nickel-chrome post & core.

This study evaluated the use of the high-performance polymer PEEK as an intraradicular post-core material by comparing it with conventional post-core materials. For a post-core restored endodontically treated tooth, a root fracture is an undesirable incident. According to previous studies, one of the causes of root fracture of post-restored teeth is stress concentration around the post-apex [26]. Clinically, the use of high elastic modulus metal posts and cores in endodontically treated teeth often leads to vertical root fractures, which can necessitate tooth extraction. To avoid these catastrophic fractures, prefabricated fibreglass posts and resin cores are now employed as post and core systems. Fibreglass, with its lower elastic modulus compared to metal but comparable strength, creates more favourable stress distributions within the root and typically results in repairable horizontal fractures if a root fracture occurs. However, despite having a lower elastic modulus than metal, fibreglass still has an elastic modulus several times greater than that of dentin. Recently, the high-performance polymer PEEK with an elastic modulus lower than that of fibreglass and similar to that of dentine has been introduced as an alternative intraradicular post-core material [27]. Therefore, the present study was performed to evaluate the biomechanical behaviour and long-term safety of the PEEK post-core system in the radicular tooth structure by using 3D FEA.

To assess the influence of a post-core material on the stress distribution of the restored tooth, the magnitudes of VME stresses under functional loading conditions were examined. In two experimental groups, the highest value of VME occurred at the zirconia crown among the overall components of each restored tooth model. This result is in agreement with the previous study of Sorrentino *et al.* [28], which conducted an FEA with a tooth model composed of a post, core, and crown, and it revealed that the crown component protects the whole system in the entire post-core restored tooth mode.

Regarding the effect of post-core material on the tooth root, the maximum VME stresses were observed at the outer labial region of the root's cervical area in both cases. When comparing these scenarios, it was found that as the elastic modulus of the post-core material decreased, stress concentration tended to increase, though the difference was not significant. This finding is consistent with previous research, indicating that more rigid post-core materials are better at resisting deflection forces, resulting in reduced maximum stresses on the root [29]. According to the study by Lanza *et al.* [10], the ideal materials of post-core systems should be sufficiently elastic to accompany the natural flexural movements of the tooth, which more rigid post-core materials cannot do. A post-core material with similar biomechanical properties to dentin could be advantageous in reducing the risk of root fractures. Therefore, a more rigid post-core working against the natural function of the tooth creates zones of tension and shear at the interface of dentine to the cemented post. These tensions, the intensities of which depend on the relative rigidity differences between the root and cemented post, can cause debonding or fractures.

In terms of stress distribution along the intraradicular labial root surface, where the dentine interfaces with the cemented post, the PEEK post-core—having an elastic modulus similar to that of dentine—demonstrated a lower stress distribution profile along the root mid-line compared to the post-core materials with higher elastic moduli. Metal post-cores showed generally higher stress distribution profiles, particularly in the cervical and post-apex regions. These findings indicate that a post-core material with a lower elastic modulus, such as PEEK, is advantageous for stress distribution at the dentine-post interface, potentially leading to a more repairable root fracture mode. This observation is consistent with previous studies highlighting the significance of stress distribution at the dentine-post interface.

Regarding the mechanical properties of PEEK, its flexural strength was similar to that of dentine and lower than the metal, and it had also a lower elastic modulus than dentine. As a result, the PEEK induced lower stresses in the post-core component, due to its flexibility. However, when the post made with PEEK material with lower elastic modulus was used, the post's stress distribution and safety factor were more favoured, but rather more stress was transferred to the adjacent crown and cement, which might indicate a higher probability of debonding of post and cement debonding resulting in crown fracture. In other words, using a post material with a low elastic modulus reduces the likelihood of vertical root fractures. However, this may increase the risk of post-core restoration failure due to cement debonding. Therefore, the elastic modulus and strength of the post-cement play a crucial role in maintaining the overall stability of a tooth restored with a low elastic modulus post-core material.

The distribution of mechanical and thermal stress in the complex geometry of an endodontically treated tooth, restored with a post, depends on the geometric, physical, and thermal properties of various materials and dental tissues. However, the variable stress gradient can contribute to damage to the bonding system resulting in the crazing of the filling material and remaining dental tissues [30].

In restorative dentistry, using PEEK for post and core represents a strategic approach to future dental health. The flexibility of PEEK material facilitates the correction of angulation issues ensuring precise alignment for optimal functionality and esthetics.

While the current study is a virtual experiment using 3D Finite Element Analysis (FEA), it highlights how the elastic modulus of post-core materials can impact the likelihood of vertical tooth fractures and post-core debonding. Therefore, a thorough understanding of stress distribution and the long-term stability of the post-core restored tooth system can aid dental professionals in making informed decisions about post-core material selection, considering the amount of remaining tooth structure. It should be noted that the simulation materials of the restorative parts and oral structures used in this study were considered to be linearly elastic, homogeneous, isotropic, and ideally bonded, which is not the same as that of natural tooth structure and supporting tissues which they present heterogeneous and anisotropic behaviours [31]. However, to guarantee the accuracy of the finding, a direct comparison between the results of the FEA study and clinical trial with in-vitro studies is necessary to support or modify the outcome of the present study and evaluate the combined effects of thermal changes and mechanical loading. Therefore, further laboratory and clinical studies, including ageing effects, are required to verify and supplement the present study.

5. Conclusion

Based on the results of this study, the following conclusions may be drawn:

- PEEK post-core, with a lower elastic modulus than dentine, exhibited a favourable stress distribution profile at the intraradicular surface, indicating a lower possibility of root fracture than conventional post-core materials.
- PEEK models transferred higher stresses to the interface material and restorative crown than the other models due to its flexibility. The probability of debonding and crown failure in a PEEK post-core system may be higher than that of rigid post-core systems.

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References

1. Ibrahim RO, AL-ZAHAWI AR, Sabri LA. Mechanical and thermal stress evaluation of PEEK prefabricated post with different head design in endodontically treated tooth: 3D-finite element analysis. Dent Mater J. 202;40(2):508-18. https://doi.org/10.4012/dmj.2020-053
2. Polesel A. Restoration of the endodontically treated posterior tooth. G Ital Endod. 2014;28: 2-16. https://doi.org/10.1016/j.gien.2014.05.007
3. Hargrevaves KM, Berman LH. Cohen pathways of the Pulp. 11th ed. St. Louis, Missouri: Elsevier; 2016. p.824.
4. Veríssimo C, Simamoto Júnior PC, Soares CJ, Noritomi PY, Santos-Filho PC. Effect of the crown, post, and remaining coronal dentin on the biomechanical behavior of endodontically treated maxillary central incisors. J Prosthet Dent. 2014;111:234-46. https://doi.org/10.1016/j.prosdent.2013.07.006
5. Badami V, Ketineni H, Pb S, Akarapu S, Mittapalli SP, Khan A:Comparative evaluation of different postmaterials on stress distribution in endodontically treated teeth using the finite element analysis method: asystematic review. Cureus. 2022;14(9):e29753. https://doi.org/10.7759/cureus.29753
6. Baba NZ, GoldenG, Goodacre CJ. Nonmetallic prefabricated dowels: a review of compositions, properties, laboratory, and clinical test results. J Prosthodont. 2009;18:527-36. https://doi.org/10.1111/j.1532-849X.2009.00464.x
7. Al-Qarni FD. Customized post and cores fabricated with CAD/CAM technology: a literature review. Int J Gen Med. 2022;15:4771-9. https://doi.org/10.2147/IJGM.S365296
8. Lee KS, Shin JH, Kim JE, Kim JH, Lee WC, Shin SW, Lee JY. Biomechanical evaluation of a tooth restored with high performance polymer PEKK post-core system: A 3D finite element analysis. BioMed Res Int. 2017;2017(1):1373127. https://doi.org/10.1155/2017/1373127
9. Newman MP, Yaman P, Dennison J, Rafter M, Billy E., Fracture resistance of endodontically treated teeth restored with composite posts. J Prosthet Dent. 2003;89(4):360–367. https://doi.org/10.1067/mpr.2003.75
10. Lanza A, Aversa R, Rengo S, Apicella D, Apicella A. 3D FEA of cemented steel, glass and carbon posts in a maxillary incisor. Dent Mater. 2005; 21(8):709–715. https://doi.org/10.1016/j.dental.2004.09.010
11. Sakaguchi RL and Powers JM, Craig's Restorative Dental Materials. Elsevier Health Sciences, 2012.
12. Ashraf MC, Sujesh M, Ravikumar C, Rajanikanth A, Duggineni CR, Sunitha K. An overview of applications of PEEK polymer in prosthodontics. Int J Dent Mater. 2022;4(2):42-5. https://doi.org/10.37983/IJDM.2022.4204
13. Rocha RF, Anami LC, Campos TM, Melo RM, Souza RO, Bottino MA. Bonding of the polymer polyetheretherketone (PEEK) to Human dentin: Effect of surface treatments. Braz Dent J 2016;27:693-699. https://doi.org/10.1590/0103-6440201600796
14. Song CH, Choi JW, Jeon YC, Jeong CM, Lee SH, Kang ES, et al. Comparison of the microtensile bond strength of a polyetherketoneketone (PEKK) tooth post cemented with various surface treatments and various resin cements. Mater (Basel). 2018;11: 916. https://doi.org/10.3390/ma11060916
15. Fuhrmann G, Steiner M, Freitag-Wolf S, Kern M. Resin bonding to three types of polyaryletherketones (PAEKs)- durability and influence of surface conditioning. Dent Mater. 2014;30(3):357–363. https://doi.org/10.1016/j.dental.2013.12.008
16. Toth JM, Wang M, Estes BT, Scifert JL, Seim III HB, Turner AS. Polyetheretherketone as a biomaterial for spinal applications. Biomater. 2006;27(3):324–334. https://doi.org/10.1016/j.biomaterials.2005.07.011
17. Lee JH. Fabricating a custom zirconia post-and-core without a post-and-core pattern or a scan post. J Prosthet Dent. 2018;120:186-9. https://doi.org/10.1016/j.prosdent.2017.10.004
18. Bittner N, Hill T, Randi A. Evaluation of a one-piece milled zirconia post and core with different post-and-core systems: an in vitro study. J Prosthet Dent. 2010;103:369-79.

https://doi.org/10.1016/S0022-3913(10)60080-7
19. Huysmans MC, Van der Varst PG. Finite element analysis of quasistatic and fatigue failure of post and cores. J Dent. 1993;21(1):57-64. https://doi.org/10.1016/0300-5712(93)90054-T
20. Jain Y, Kumar S. Stress analysis using photoelasticity technique–a review. Int J Res Appl Sci Eng Technol. 2017;5(VIII):2066-70. https://doi.org/10.22214/ijraset.2017.8293
21. Yoon HG, Oh HK, Lee DY, Shin JH. 3-D finite element analysis of the effects of post location and loading location on stress distribution in root canals of the mandibular 1st molar. J Appl Oral Sci. 2018;26:e20160406. https://doi.org/10.1590/1678-7757-2016-0406
22. Carvalho MA, Lazari PC, Gresnigt M, Del Bel Cury AA, Magne P. Current options concerning the endodonticallytreated teeth restoration with the adhesive approach. Braz Oral Res 2018; 32: e74. https://doi.org/10.1590/1807-3107bor-2018.vol32.0074
23. Nanda SM, Nanda T, Yadav K, Sikka N. Fibre post & all ceramic crown —a simple approach to the perfect smile. Sch J Dent Sci. 2015;2:247-249.
24. Al-Omiri MK, Mahmoud AA, Rayyan MR, Abu-Hammad O. Fracture resistance of teeth restored with post-retained restorations: an overview. J Endod. 2010;36:1439-1449. https://doi.org/10.1016/j.joen.2010.06.005
25. Schwartz RS, Robbins JW. Post placement and restoration of endodontically treated teeth: a literature review. J Endod. 2004;30: 289-301. https://doi.org/10.1097/00004770-200405000-00001
26. Komada W, Miura H, Okada D, Yoshida K. Study on the fracture strength of root reconstructed with post and core: alveolar bone resorbed case. Dent Mater J. 2006; 25(1):177–182. https://doi.org/10.4012/dmj.25.177
27. Dilmener FT, Sipahi C, Dalkiz M. Resistance of three new esthetic post-and-core systems to compressive loading. J Prosthet Dent. 2006;95(2):130–136. https://doi.org/10.1016/j.prosdent.2005.11.013
28. Sorrentino R, Aversa R, Ferro V, Auriemma T, Zarone F, Ferrari M, Apicella A. Three-dimensional finite element analysis of strain and stress distributions in endodontically treated maxillary central incisors restored with diferent post, core and crown materials. Dent Mater. 2007;23(8):983-93. https://doi.org/10.1016/j.dental.2006.08.006
29. Dejak B, Młotkowski A. Finite element analysis of strength and adhesion of cast posts compared to glass fiber-reinforced composite resin posts in anterior teeth. J Prosthet Dent. 2011;105(2):115-26. https://doi.org/10.1016/S0022-3913(11)60011-5
30. Pałka K, Bieniaś J, Dębski H, Niewczas A. Finite element analysis of thermo-mechanical loaded teeth. Comput Mater Sci. 2012;64:289-294. https://doi.org/10.1016/j.commatsci.2012.05.037
31. Celebi AT, Icer E, Eren MM, Baykasoglu C, Mugan A, Yildiz E. Thermal-stress analysis of ceramic laminate veneer restorations with different incisal preparations using micro-computed tomography-based 3D finite element models. J Mech Behav Biomed Mater. 2017;75:302-13.

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