ISSN: 2717-8161 RESEARCH ARTICLE

New Trends in Medicine Sciences

New Trend Med Sci 2024; 5(2):53-59. https://dergipark.org.tr/tr/pub/ntms

The Effect of Surface Properties of Different Types of Post Materials on Fracture Type

Başak Topdağı[1*], Funda Bayındır[2]

[1]Department of General Dentisty, Sultan 2. Abdulhamit han training and research Hospital, Health Science University, İstanbul, Türkiye
[2]Deparment of Prosthetic Dentistry, Faculty of Dentistry, Atatürk University, Erzurum, Türkiye

Article History
Received 01 March 2024
Accepted 20 March 2024
Published Online 30 May 2024

Corresponding Author
Başak Topdağı
Department of General Dentisty
Sultan 2. Abdulhamit han training and research Hospital
Health Science University
İstanbul, Türkiye
Phone: +90 5368455552
E-mail: basaktopdagi@gmail.com

Doi:10.56766/ntms.1445445

Authors' ORCIDs
Başak Topdağı
http://orcid.org/0000-0002-4242-7681
Funda Bayındır
http://orcid.org/0000-0001-5699-2879

Abstract: In this article, it is aimed to examine the fracture strength of peek posts to the ferrule under provided and unprovided conditions.66 extracted human central incisors were used (n=11) from Ni-Cr alloy, fiber, and peek materials to form six groups (N, NF, F, FF, P, and PF). Crown materials, compatible with the central maxillary incisor anatomy, were produced for 66 samples. Subsequently, the samples were subjected to fracture strength testing. After the test, the samples were classified into three groups based on the type of fracture: adhesive, cohesive, and mixed. The significance of the difference between the groups was evaluated statistically. The surface roughness value of the peek post group (1.42±0.21) was significantly lower than that of the metal and fiber post groups. Although no significant difference was found in terms of the fracture type, the adhesive failure rate was higher in the peek post group ($P<0.05$). Adhesive type joint failure is most commonly seen in non-ferrule and ferrule peep post groups ©2024 NTMS.

Keywords: Fracture strength; polietereterketon; surface properties.

1. Introduction

The prognosis of teeth undergoing endodontic treatment is influenced by many factors[1-3]. When the coronal tissue loss is 50% or more, post-core treatment can be applied to ensure continuity of the remaining dental tissues [4, 5]. Additionally, it is known that the ferrule effect and the amount of remaining dental tissue also increase the resistance of the tooth to fracture [6, 7] Ferrule is defined as a vertical band surrounding the tooth structure in the gingival region during crown preparation [8, 9]. Previous literature studies have observed that even a 1 mm ferrule effect is a minimum width effective in stabilizing restoration. Than Whang et al [10]. Fontana et al. observed that the effect of a 0.5 mm ferrule width was low [11]. Studies have shown that ferrule height is more important in terms of durability. The minimum ferrule height required for post-core restorations has been reported to be 1.5-2 mm [7, 9]. In addition to the amount of remaining dental tissue, the type of restoration and material selection are also crucial for the prognosis of endodontically treated teeth [12]. The use of prefabricated fiber posts ensures a balanced distribution of occlusal forces on the tooth [13]. These systems have various advantages and disadvantages. The use of prefabricated fiber posts ensures a balanced distribution of occlusal forces on the tooth [14].
The elastic modulus values of the metal and ceramic posts produced according to the canal structure are higher than those of dentine [15]. Furthermore, due to many disadvantages of cast post-cores, such as

Cite this article as: Topdaği, B and Bayındır F. The Effect of Surface Properties of Different Types of Post Materials on Fracture Type. *New Trend Med Sci.* 2024; 5(2):53-59.Doi:10.56766/ntms.1445445.

displaying a metallic color, corrosion, disintegration, retention loss, and root fracture formation, there has been a shift toward fiber post systems [16]. Despite being able to solve many problems associated with metal posts, fiber posts cause mechanical stress at the cervical dentine and restoration border and do not reinforce the tooth structure [17]. In addition, despite having a lower elasticity modulus than metal posts, fiber posts still have a modulus almost three times that of dentine [18]. Polyetheretherketone (PEEK) is a semi-crystalline high-performance thermoplastic polymer that has become increasingly popular in dentistry [19, 20]. Mechanical properties such as elastic modulus can also be adjusted by modifying the filler content and incorporating inorganic filler materials [21]. The dentine-like elastic modulus of PEEK allows it to function as a stress reliever that reduces the forces transferred to restorations. The fact that the elastic modulus value is close to the elastic modulus of dentin is a very good feature in terms of stress homogeneity [22].

This study aims to investigate the effect of the ferrule on the fracture resistance of posts prepared with PEEK material, which is increasingly being used in prosthetic dentistry, in addition to current post materials.

This study has two hypotheses: The first hypothesis is that the PEEK post groups will show significantly higher surface roughness than the other groups. The second hypothesis is that the frequency of adhesive fractures in the PEEK post groups does not differ from that of other materials.

2. Material and Methods

The number of teeth used in this study was calculated using parameters from a study conducted by Fontana et al.[11] based on the G*power software. The sample size was calculated for situations where the fracture resistance test results of the 'cast post-core' control group, conducted with and without a 1 mm ferrule, were 339±153 and 575±2.4 respectively.

Accordingly, it was calculated that each group with 80% power and 95% confidence level should consist of 11 maxillary incisor teeth. All teeth were cleaned of soft tissue remnants and calculus and immersed in 0.1% thymol solution (*Thymol; Supelco®, Missouri, USA)*. 66 teeth were randomized into 6 subgroups. The group scheme is shown in Table 1.

2.1. Simulation of Periodontal Ligament

The modeling wax used to simulate the periodontal ligament within an acrylic model was liquefied at 65 °C. A 0.2 mm thick layer of wax was applied to each tooth root, starting 3mm coronally from the apex. The teeth were then embedded in a delrin (polyoxymethylene) cylinder after applying autopolymerizing acrylic resin (*Integra*) onto the wax layer. An elastomeric impression material was used to mimic the periodontal ligament (*Impregum F, 3M-ESPE, Seefeld, Germany).*

Table 1: Study design.

Post Type	Ferrule Thickness	Group Code
PEEK	Non-ferrule	P
PEEK	2mm height with 1mm thickness ferrule effect	PF
Metal	Non-ferrule	N
Metal	2mm height with 1mm thickness ferrule effect	NF
Fiber	Non-ferrule	F
Fiber	2mm height with 1mm thickness ferrule effect	FF

2.2. Endodontic Treatment Procedure

The crowns of the teeth were removed using a high-speed handpiece with a diamond bur, leaving a root length of 10mm behind. Teeth with single and straight root canals were used, with root lengths of at least 10 mm each. A standard endodontic protocol was applied.

2.3. Canal Preparation for Post Space

The length of the post space was designed to be 1 mm for groups without ferrules and 12 mm for groups with a ferrule height of 2 mm.

2.4. Ferrule Preparation

In their study of ferrule length, Libman and Nicholls [23] showed that 0.5 mm and 1.0 mm ferrule lengths were significantly less successful at a lower number of cycles compared with 1.5 mm and 2.0 mm ferrule lengths. Therefore, a ferrule of 2 mm height and 1 mm width was prepared. For CP-1, PP-1, and FP-1 groups, ferrule preparation was manually performed using a high-speed water-cooled micromotor with a diamond bur attached (*Extra Torque 605C; Kavo do Brasil, Joinville) (No.3216, KG Sorensen, Barueri, Brazil)* (Figure 1 A, B).

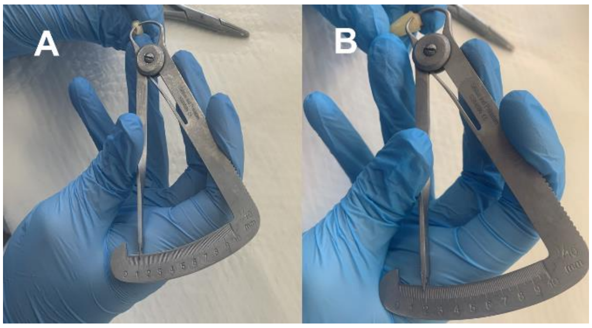

Figure 1: Ferrule preparation; A. 1mm diameter. B. 2mm height.

2.5. Post Production

For cast and PEEK posts, plastic dowels (*Pinjet Angelus*, *Londrina, Parana, Brazil*) were coated with chemically activated acrylic resin (*Bosworth Trim Plus Company*, *Skokie, IL, USA*). The production of PEEK posts involved indirect measurement from the canal, transferring it into a digital format using a digital scanner (*Shining 3D EinScan H 3D Scanner VHF K5*) (Figure 2). All completed post types are shown in Figure 3.

Figure 2: CAD-CAM image of the designed PEEK post sample.

2.6. Surface Treatments

All the samples were cleaned with 70% ethanol after production and dried. Subsequently, phosphoric acid (*K Etchant GEL; Kuraray, Umeda, Osaka, Japan*) was applied to the fiber post surfaces, according to the manufacturer's instructions. After 15 s of acid application, the fiber surfaces were rinsed with water. The surface treatment of the PEEK post groups was achieved by applying 98% sulfuric acid to the material surface for 60 s. Following the acid treatment, the materials were washed with distilled water for one minute and dried. Surface treatments for cast posts were conducted by spraying Al_2O_3 particles of 15-nanometer particle size onto the post surface at a pressure of 50 Mpa for 15 s.

Figure 3: All post materials and corresponding tooth specimens.

2.7. Surface Measurements and Surface Observation

The surface roughness (*Ra*) of the surface-treated post materials was measured using a noncontact profilometer (*3D noncontact profilometer Kla Tencor Stylus Profiler P7*). Following the surface treatment, the structural surface topography of each group was observed under a scanning electron microscope.

2.8. Application and Cementation of Post Materials into the Canal

All posts were fixed in the canal with dual cure resin cement (*Allcem, FGM*).

Table 2: ANOVA results for fracture resistance test outcomes.

Group Number	Fracture Resistance (N)	Standard Deviation	Median	Minimum	Maximum	F	P
CP-0	415.0300	126.4174	412.4400	182.3600	642.7600		
CP-1	555.7564	112.1193	559.2190	359.7890	775.1420		
FP-0	310.8080	998.8239	312.4499	163.5478	458.9001		
FP-1	322.4682	109.1813	320.0600	141.5800	508.2200	7.565	P<0.05
PP-0	341.2164	129.6218	330.6500	120.5600	534.6500		
PP-1	377.6036	115.9855	364.0800	173.4500	558.1500		

2.9. Core Production

A composite resin (*Opallis, FGM*) was used for core production. To ensure standardization of the core material across all groups, a previously prepared acetate matrix post system was adapted to the coronal portion.

2.10. Aging Procedure

The samples were aged by keeping them at 5°C for 20 seconds and at 55°C for 20 seconds in a machine (Acumen III; MTS Systems Corp.) simulating the oral environment and by subjecting them to 6000 thermal cycles, with 20 seconds between cycles, to correspond to a five-year service period in the mouth, and were then subjected to the fracture resistance test. After aging and fracture strength testing, the types of fractures (adhesive, cohesive, and mixed), fracture locations (buccal, palatal, mesial, and distal), and reparability of fractures (requiring extraction and repairable) were evaluated using an optical microscope.

Table 3: ANOVA results for roughness values.

Group Number	Surface Roughness (Ra)	Standard Deviation	Median	Minimum	Maximum	F	P
N	2.13	0.13	2.13	1.91	2.29		
NF	2.15	0.14	2,25	1.92	2.32		
F	2.86	0.09	2.95	2.78	3.16	314.321	0.000
FF	2.86	0.15	2.93	2.69	3.21		
P	1.65	0.08	1.66	1.53	1.77		
PF	1.64	0.05	1.65	1.53	1.73		

2.11. Fracture Strength Test

Fracture tests were conducted on the palatal region of the zirconia crown material at a low speed (1 mm/min) and an angle of 135 to the long axis of the tooth, using a universal testing machine (*Model 4202; Instron*). At the end of the test, each sample was examined under an optical microscope at x10 magnification to determine its fracture mode. Root fractures were classified as catastrophic, to be extracted, or repairable.

2.12. Statistical Analysis

Analyses were conducted using IBM SPSS 20 statistical analysis software. For the comparison of continuous variables among more than two independent groups, the ANOVA. Pearson chi-squared and the Fisher-Freeman-Halton test was used when it post-hoc. Statistical significance was set at $p<0.05$.

3. Results

The average maximum fracture resistance of the six different experimental groups exceeded the maximum force values (286 N) reported in the literature for the anterior region [40]. According to the fracture resistance test results, the groups with metal custom posts (N and NF) demonstrated higher fracture resistance than the other groups. According to the ANOVA test results, cast post specimens with ferrule preparation (NF) exhibited a significantly higher fracture resistance ($p<0.05$). Table 2 presents the statistical results of the fracture resistance test values according to the ANOVA.

Table 4: Freeman-Halton test results.

Group no (n=66)	N	NF	F	FF	P	PF	Total	P
Adhesive	7	2	6	7	8	8	43	
Cohesive	2	0	0	0	0	0	2	0.857
Mixed	2	4	5	4	3	3	21	

Table 4 displays the results of examining fracture types under an optical microscope and the analysis of fracture types using the Fisher-Freeman-Halton test. Based on the failure mode of the bonding mechanism of the samples subjected to fracture testing, the fracture types occurring on the posts were observed under an optical microscope (x10), and statistical analysis of the fracture types was conducted. Significant differences were found among the groups. The rate of adhesive fractures was significantly higher in the PEEK and fiber post groups than in the other groups ($p<0.05$). There was no significant difference between the fiber (F, FF) and PEEK (P, PF) post groups ($p>0.05$).

4. Discussion

This study has two hypotheses: The first hypothesis posited that the peek post groups would exhibit significantly higher surface roughness than the other groups. Since the fiber post groups showed significantly higher fracture resistance than the other post groups, the first hypothesis of the study was rejected. Many other studies in the literature concerning fiber posts have similarly reported high surface roughness values. The second hypothesis was that adhesive fractures would not differ significantly between the Peek post groups and other materials.

However, as adhesive fracture frequency was found to be significantly higher in the Peek post groups than in the other groups, the second hypothesis of the study was also rejected.

This finding is consistent with those of many previous studies [24, 25]. Atais Bacchi et al.[26] similarly investigated the 'ferrule effect' on fracture resistance in finite element analysis studies involving metal and glass fiber posts, both with and without observed ferrule effect conditions, and found that the 'ferrule effect' increased fracture resistance independently of the materials examined ($p<0.05$). Michael Naumann et al. [27] in their systematic review, similarly concluded that the 'ferrule effect' had a much larger impact than the various material types used.

In this study, it was measured that the fracture resistance test values observed were higher than the known values for anterior teeth (190-290N) When the test results were examined, it was observed that the fracture resistance values of NF were significantly higher than those of all groups ($p<0.05$). This situation is consistent with the literatüre [28] . Similarly, a previous study examined two experimental post groups; prefabricated fiber posts with composite cores and cast post cores with 2 mm ferrule preparation. It was observed that the fracture resistance of the metal post core group was significantly higher than that of the other group [29]. In the study conducted by Fraga et al., among the experimental groups with 2mm ferrule preparation, metal post cores exhibited significantly higher statistical fracture resistance compared with those of prefabricated fiber posts with composite cores. It has been reported in previous similar studies that 2 mm ferrule preparation significantly increased the fracture resistance of cast metal posts [30]. Although not statistically significant, the fracture resistance values of the Peek post groups were higher than those of the fiber post groups. Similarly, in a study using extracted premolar teeth, the fracture resistance values of the Peek post group were higher, but no statistically significant difference was found [31].

Kul et al.[32] examined the fracture strengths of zirconia ceramic posts, fiber posts, and glass fiber-reinforced composite resin posts. Similar to this study, they observed that all samples without ferrule preparation fractured catastrophically. In conditions where the ferrule effect was not achieved, the use of Peek posts may be considered a more advantageous option than previously tested materials. However, in this study, it does not seem sufficient to prevent the formation of irreparable fractures. In vivo studies are needed to restore real teeth with Peek posts, where the periodontal feedback mechanism is present.

When the groups with ferrule preparation were examined, it was observed that the likelihood of catastrophic fracture was much higher in the metal groups with high fracture resistance (81.1%). The frequency of catastrophic fractures in NF was observed to be statistically significantly high ($p<0.05$). Previous studies have reached a consensus that regardless of the presence of the ferrule effect, metal posts lead to catastrophic fractures in the root. [33] The frequency of repairable fractures in PF was found to be statistically high ($p<0.05$). Using peek posts reduces the incidence of catastrophic fractures [31]. However, there are relatively few studies on this subject.

Surface roughness is a critical factor in adhesive procedures and requires various surface treatment methods to enhance the bonding area and micro-roughness of dental materials [34]. Peek, as confirmed by SEM images, exhibited pits and pores distributed with filler particles on the surface, as shown in previous studies [35]. The measured surface roughness values for all examined experimental groups are consistent with the Ra values found in the literature [36, 37]. When surface roughness values were examined, fiber post groups (F, FF) showed significantly higher roughness values than all other materials ($p<0.05$). This may be attributed to the difficulty of surface treatments for metal posts and the chemically inert nature and low surface energy of Peek post materials [38].

After the fracture resistance test, when the failure modes of the extracted samples were examined, predominantly adhesive failures were observed. There was no significant difference between the fiber and Peek post groups ($p > 0.05$). Adhesive failures observed in the PEEK and fiber post groups were significantly higher than those in metal post groups ($p>0.05$). This is thought to be due to the much higher fracture resistance of metal post groups, resulting in the formation of fracture lines comprising dental structures [39]. For groups F and FF, some resin residues were observed adhering to the post surface, but this group primarily fractured in the adhesive type as observed in previous studies [40].

5. Conclusion

1.The reason for the significantly higher occurrence of fracture lines comprising dental structures in the metal post groups is thought to be due to the significantly higher fracture resistance values exhibited by the metal post ($p<0.05$).

2.The incidence of adhesive type failure in peek and fiber posts is significantly higher than in other types of materials used in this study ($p<0.05$).

Limitations of the Study

This article has certain limitations:

1.This study is an in vitro study and cannot encompass many factors in the oral environment, particularly feedback mechanisms.

2.The produced zirconia crowns are designed to serve as a substructure material and are relatively smaller in size compared to the actual central tooth dimensions.

Acknowledgement

None.

Conflict of Interests

There is no conflict of interest.

Financial Support

This study was supported within the scope of a basic research project Atatürk University (Project code: TSA-2021-9823).

Author Contributions
Conception: BT, FB. Design: BT, FB. Supervision: BT, FB. Materials: BT, FB. Data Collection and/or Processing: BT, FB. Analysis and Interpretation: BT, FB. Literature: BT, FB. Review: BT, FB. Writing: BT, FB. Crital Review: BT, FB.

Ethical Approval
This study was approved by the etic committee of Atatürk University Faculty of Dentisty (No: 34).

Data sharing statement
It is mentioned in the article that all the data supporting the results are provided within the article itself and there is no need for additional source data.

Consent to participate
None.

Informed Statement
None.

References

1. Fráter M, Sáry T, Néma V, Braunitzer G, Vallittu P, Lassila L, Garoushi S. Fatigue failure load of immature anterior teeth: influence of different fiber post-core systems. *Odontology.* 2021; 109:222-30.

2. Topçuoğlu HS, Demirbuga S, Tuncay Ö, Pala K, Arslan H, Karataş E. The effects of Mtwo, R-Endo, and D-RaCe retreatment instruments on the incidence of dentinal defects during the removal of root canal filling material. *J Endod.* 2014; 40(2):266-70.

3. Alqarawi FK, Alkahtany MF, Almadi KH, Ben Gassem AA, Alshahrani FA, AlRefeai MH, Farooq I, Vohra F, Abduljabbar T. Influence of different conditioning treatments on the bond integrity of root dentin to rGO infiltrated dentin adhesive. SEM, EDX, FTIR and microRaman study. *Polymers.* 2021; 13(10):1555.

4. Ferrari M, Vichi A, Grandini S, Goracci C. Efficacy of a Self-Curing Adhesive--Resin Cement System on Luting Glass-Fiber Posts into Root Canals: An SEM Investigation. *Int J Prosthodont.* 2001; 14(6):543-49.

5. Cheung W. A review of the management of endodontically treated teeth: Post, core and the final restoration. *JADA.* 2005; 136(5):611-19.

6. Sorensen JA, Engelman MJ. Ferrule design and fracture resistance of endodontically treated teeth. *J Prosthet Dent.* 1990; 63(5):529-36.

7. Akkayan B. An in vitro study evaluating the effect of ferrule length on fracture resistance of endodontically treated teeth restored with fiber-reinforced and zirconia dowel systems. *J Prosthet Dent.* 2004; 92(2):155-62.

8. Fráter M, Sáry T, Braunitzer G, Szabó PB, Lassila L, Vallittu PK, Garoushi S. Fatigue failure of anterior teeth without ferrule restored with individualized fiber-reinforced post-core foundations. *JMBBM.* 2021; 118:104440.

9. Stankiewicz N, Wilson P. The ferrule effect: a literature review. *Int Endod J.* 2002:35(7):575-81.

10. Tjan AH, Whang SB. Resistance to root fracture of dowel channels with various thicknesses of buccal dentin walls. *J Prosthet Dent.* 1985; 53(4):496-500.

11. 1Fontana P, Bohrer T, Wandscher V, Valandro L, Limberger I, Kaizer O. Effect of ferrule thickness on fracture resistance of teeth restored with a glass fiber post or cast post. *Oper Dent.* 2019; 44(6):E299-E308.

12. Yang A, Lamichhane A, Xu C. Remaining coronal dentin and risk of fiber-reinforced composite post-core restoration failure: a meta-analysis. *International Journal of Prosthodontics.* 2015; 28(3):258-64.

13. Lassila LV, Tezvergil A, Lahdenperä M, Alander P, Shinya A, Shinya A, Vallittu PK. Evaluation of some properties of two fiber-reinforced composite materials. *Acta Odontol Scand.* 2005; 63(4):196-204.

14. Grandini S, Goracci C, Monticelli F, Tay FR, Ferrari M. Fatigue resistance and structural characteristics of fiber posts: three-point bending test and SEM evaluation. *Dent Mater J.* 2005; 21(2):75-82.

15. Cathro P, Chandler N, Hood J. Impact resistance of crowned endodontically treated central incisors with internal composite cores. *Dent Traumatol.* 1996; 12(3):124-28.

16. Fredriksson M, Astbäck J, Pamenius M, Arvidson K. A retrospective study of 236 patients with teeth restored by carbon fiber-reinforced epoxy resin posts. *J Prosthet Dent.* 1998; 80(2):151-57.

17. Miura H, Yoshii S, Fujimoto M, Washio A, Morotomi T, Ikeda H, Kitamura C. Effects of both fiber post/core resin construction system and root canal sealer on the material interface in deep areas of root canal. *Materials.* 2021; 14(4):982.

18. Soliman M, Alshamrani L, Yahya B, Alajlan G, Aldegheishem A, Eldwakhly E. Monolithic Endocrown Vs. Hybrid Intraradicular Post/Core/Crown Restorations for Endodontically Treated Teeth; Cross-sectional Study. *Saudi J Biol Sci.* 2021; 28(11):6523-31.

19. Henriques B, Fabris D, Mesquita-Guimarães J, Sousa AC, Hammes N, Souza JC, Silva FS, Fredel MC. Influence of laser structuring of PEEK, PEEK-GF30 and PEEK-CF30 surfaces on the shear bond strength to a resin cement. *JMBBM.* 2018; 84:225-34.

20. Li P, Hasselbeck D, Unkovskiy A, Sharghi F, Spintzyk S. Retentive Characteristics of a Polyetheretherketone Post-Core Restoration with Polyvinylsiloxane Attachments. *Polymers.* 2020; 12(9):2005.

21. Ozarslan M, Buyukkaplan US, Ozarslan MM. Comparison of the fracture strength of endodontically treated teeth restored with polyether ether ketone, zirconia and glass-fiber post-core systems. *Int J Clin Pract.* 2021; 75(9):e14440.

22. Stawarczyk B, Jordan P, Schmidlin PR, Roos M, Eichberger M, Gernet W, Keul C. PEEK surface treatment effects on tensile bond strength to veneering resins. *J Prosthet Dent.* 2014; 112(5):1278-88.

23. Libman WJ, Nicholls JI. Load fatigue of teeth restored with cast posts and cores and complete crowns. *Int J Prosthodont.* 1995; 8(2): 155-61.

24. Juloski J, Radovic I, Goracci C, Vulicevic ZR, Ferrari M. Ferrule effect: a literature review. *J Endod.* 2012; 38(1):11-19.

25. Tan PL, Aquilino SA, Gratton DG, Stanford CM, Tan SC, Johnson WT, Dawson D. In vitro fracture resistance of endodontically treated central incisors with varying ferrule heights and configurations. *J Prosthet Dent.* 2005; 93(4):331-36.

26. Bacchi A, Caldas RA, Schmidt D, Detoni M, Souza MA, Cecchin D, Farina AP. Fracture strength and stress distribution in premolars restored with cast post-and-cores or glass-fiber posts considering the influence of ferule. *BioMed Res Int.* 2019; 2196519

27. Naumann M, Schmitter M, Frankenberger R, Krastl G. "Ferrule comes first. Post is second!" Fake news and alternative facts? A systematic review. *J Endod.* 2018; 44(2):212-19.

28. Pereira JR, De Ornelas F, Conti PCR, Do Valle AL. Effect of a crown ferrule on the fracture resistance of endodontically treated teeth restored with prefabricated posts. *J Prosthet Dent.* 2006; 95(1):50-54.

29. Zhi-Yue L, Yu-Xing Z. Effects of post-core design and ferrule on fracture resistance of endodontically treated maxillary central incisors. *J Prosthet Dent. 2003; 89(4):368-73.*

30. Qing H, Zhu Z, Chao Y, Zhang W. In vitro evaluation of the fracture resistance of anterior endodontically treated teeth restored with glass fiber and zircon posts. *The J Prosthet Dent.* 2007; 97(2):93-98.

31. Pourkhalili H, Maleki D. Fracture resistance of polyetheretherketone, Ni-Cr, and fiberglass postcore systems: An in vitro study. *Dent Res J.* 2022; 19:20.

32. Kul E, Yanıkoğlu N, Yeter KY, Bayındır F, Sakarya RE. A comparison of the fracture resistance of premolars without a ferrule with different post systems. *J Prosthet Dent.* 2020; 123(3):523.e1-e5.

33. Sahafi A, Peutzfeldt A, Ravnholt G, Asmussen E, Gotfredsen K. Resistance to cyclic loading of teeth restored with posts. *Clin Oral Invest.* 2005; 9:84-90.

34. Rosentritt M, Preis V, Behr M, Sereno N, Kolbeck C. Shear bond strength between veneering composite and PEEK after different surface modifications. *Clin Oral Investigat.* 2015; 19:739-44.

35. Schmidlin PR, Stawarczyk B, Wieland M, Attin T, Hämmerle CH, Fischer J. Effect of different surface pre-treatments and luting materials on shear bond strength to PEEK. *Dent Mat J.* 2010:; 26(6):553-59.

36. Bezzon OL, Pedrazzi H, Zaniquelli O, da Silva TBC. Effect of casting technique on surface roughness and consequent mass loss after polishing of NiCr and CoCr base metal alloys: a comparative study with titanium. *J Prosthet Dent.* 2004; 2(3):274-47.

37. Chaijareenont P, Prakhamsai S, Silthampitag P, Takahashi H, Arksornnukit M. Effects of different sulfuric acid etching concentrations on PEEK surface bonding to resin composite. *Dent Mat J.* 2018; 37(3):385-92.

38. Lee K-S, Shin M-S, Lee J-Y, Ryu J-J, Shin S-W. Shear bond strength of composite resin to high performance polymer PEKK according to surface treatments and bonding materials. *J Adv Prosthodont.* 2017; 9(5):350-57.

39. Shafiei F, Behroozibakhsh M, Abbasian A, Shahnavazi S. Bond strength of self-adhesive resin cement to base metal alloys having different surface treatments. *Dent Res J.* 2018; 15(1):63.

40. Ahmet BSO, Egilmez F, Ergun G, Nagas IC. Surface treatment effects on bond strength of CAD/CAM fabricated posts to root canal dentin. *Am J Dent*. 2019; 32(3):113-17.

NTMS New Trends in Medicine Sciences
https://dergipark.org.tr/tr/pub/ntms