



Evaluation of Fracture Resistance and Failure Pattern of Endodontically Treated Teeth Restored with Polyether Ether Ketone (PEEK) Post Associated with no, 1mm and 2mm Crown Ferrule Lengths

Prachi Taori ^{a†} and Pradnya Nikhade ^{a‡}

^a *Department of Conservative Dentistry and Endodontics, Sharad Pawar Dental College, Datta Meghe Institute of Medical Sciences, Sawangi (M), Wardha, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JPRI/2021/v33i60B34949

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/80052>

Study Protocol

Received 22 October 2021
Accepted 25 December 2021
Published 27 December 2021

ABSTRACT

Background: There is constant advancement in aesthetic material used in dentistry due to constant increase in demand of aesthetics.

Objectives:

1. "To evaluate fracture resistance and pattern of failure of ETT restored with PEEK post with no ferule."
2. "To evaluate fracture resistance and pattern of failure of ETT restored with PEEK post with 1mm ferule length."
3. "To evaluate fracture resistance and pattern of failure of ETT restored with PEEK post with 2mm ferule length."
4. "To compare the above groups with each other."

Methods: 30 human RC treated mandibular premolar teeth with single root will be decoronated at CEJ, 1mm and 2mm above CEJ & will be prepared to receive PEEK post which will be divided into 3 groups (n = 10) according to corresponding ferrule length.

After treatment of surface, post will be cemented using luting cement that is self-adhesive. Following thermocycling, they will be subjected to compressive static load at 45° angulation until

[†]MDS 1st year;

[‡]Professor and Head of the Department;

*Corresponding author: E-mail: drprachitaori@gmail.com;

there is fracture. Later analysis will be done with one-way ANOVA and Tukey's HSD post hoc comparison test.

Results: Although root canal treated tooth with higher ferrule height shows higher fracture resistance in previous studies, but it would be something interesting if the use of PEEK post can improve fracture resistance of root canal treated tooth with ferrule height less than 2mm.

Conclusion: From the results of this study we will be able to conclude that if coronal dentinal structure is increased, resistance to fracture of ETT is increased remarkably.

Keywords: RCT teeth; poly ether ether ketone endodontic post; fracture resistance.

1. INTRODUCTION

The teeth which are most prone to fracture are those which are endodontically treated because of loss of dentin in its coronal and radicular portion [1]. Added features such as compromised tactile sense, various irrigant used and communication of bacteria-dentin too contribute to biologic and mechanical failure [2]. Therefore, it is necessary to restore the ETT so that coronal leakage would be less and aesthetic and function would be restored [3-6]. So for this purpose, endodontic post should be used. Post attributes mainly to retention of core restoration. In today's world, as aesthetic is utmost priority for most of the patient, aesthetic post like resin fibre post, zirconia post, poly ether ether ketone post etc. are getting popular. Endodontic post must have better tensile strength, proper fitting, enough fracture strength so that masticatory forces are evenly distributed [7]. According to many researchers, if the elastic modulus of post is matching with the dentin then catastrophic root fracture can be prevented.

Polyether ether ketone, a semi-crystalline better acting thermoplastic resin polymer which has superior thermal, chemical & mechanical properties, fatigue resistance, less absorption of water and better biocompatibility is getting popular in dentistry [8-11]. And if we alter the filler content like adding inorganic filler, then we can expect better mechanical properties like modulus of elasticity. The elastic modulus of polyether ether ketone post is similar to dentin and this is the main advantage due to which less forces are transferred to restoration and thus this material can function as stress breaker. Also, as this material is radiolucent, treatment steps can be better evaluated. Fracture resistance of this material is high, fracture load being 1383N, so this can be used in place of glass ceramic and metal. The post can be customized according to prepared root canal as it is made using CAD/CAM. This prevents excessive cutting of

root canal. Also this reduces amount of luting cement & has better resistance to friction.

Tooth fracture still continues to occur even if they are restored with post and core [12]. 2 mm crown ferrule increases the fracture resistance. And it is believed that this tooth structure of the crown increases retention and resistance of the crown [13,14]. Many researchers proposed that there must be at least 2mm of ferrule above CEJ so that tooth should have proper resistance form [14]. This tooth structure prevents root fracture, post fracture & post dislodgment. According to Gegauff, surgical crown lengthening was done and as such there was not any variation in resistance to fracture of tooth. Thus, authors have different opinion regarding remaining tooth structure.

So, this study will be conducted to evaluate effect of the tooth structure that is remaining in endodontically treated tooth in relation to fracture resistance. And it is believed that this remaining tooth structure plays major role in increasing fracture resistance of tooth.

1.1 Aim

To evaluate fracture resistance and failure pattern of endodontically treated teeth restored with polyether ether ketone (PEEK) post associated with no, 1mm and 2mm crown ferrule lengths

1.2 Objectives

1. To evaluate fracture resistance and pattern of failure of ETT restored with PEEK post with no ferrule.
2. To evaluate fracture resistance and pattern of failure of ETT restored with PEEK post with 1mm ferrule length.
3. To evaluate fracture resistance and pattern of failure of ETT restored with PEEK post with 2 mm ferrule length.

4. To compare the above groups with each other.”

with absence of caries, restoration, cracks and white spots will be selected.

1.3 Rationale

Restoring the fractured tooth or grossly carious crown has to be done to preserve the tooth. The preservation of natural tooth structure is mandatory which needs reinforcement using various techniques. This could be done by using various post and core. Hence, this newly introduced PEEK has given promising results with additional advantage of high fracture resistance, low water absorption, excellent biocompatibility, etc. Its correlation with the suitable ferrule length will be evaluated. Hence, the present study will evaluate fracture resistance and pattern of failure of ETT in which restoration will be done with PEEK post associated with various crown ferrule lengths.

2. METHODS

2.1 Source of the Data

After taking Informed consent from the patients whose teeth will be removed for orthodontic reason, to use their extracted teeth for the study. Human permanent mandibular premolars extracted teeth for orthodontic purpose will be collected from the Department of Oral Surgery, Sharad Pawar Dental College, Sawangi (M), Wardha. Among these, thirty sound healthy teeth

2.3 Study Design

Chart 1. In this analytical study, a total of 30 samples divided into three groups

The groups are as follows:

Sr no	Group	Ferrule length	Sample size
1.	Group I	“Coronal aspect of teeth will be removed at Cemento-enamel junction perpendicular to long axis of teeth”	n =10
2.	Group II	“Coronal aspect of teeth will be removed 1mm occlusal to Cemento-enamel junction perpendicular to long axis of teeth”	n =10
3.	Group III	“Coronal aspect of teeth will be removed 2mm occlusal to Cemento-enamel junction perpendicular to long axis of teeth”	n =10

2.4 Inclusion Criteria

- Lower premolars with mature apex & straight root.
- Lower premolar with no previous endodontic treatment.
- Lower premolar with single canal.

2.2 Sample Size Calculation

The sample size was calculated using; From the previous article it was proved that After applying the formula calculation are as follows,

$$n = (Z_{\alpha} + Z_{\beta})^2 (\delta_1^2 + \delta_2^2 / K) / \Delta^2$$

Where

Z_{α} = is the level of significance at 5% i.e. 95% confidence interval = 1.96

Z_{β} = is the power of test = 80% = 0.84

δ_1 = standard deviation of resistance to failure of test specimen in 1mm group = 122.6

δ_2 = standard deviation of resistance to failure of test specimen in control group = 147.9

Δ = difference between 2 mean
= 818.2 – 627.6 = 190.6

K = 1

n = 7.96

n=10 teeth in each group.

So, by above formula sample size will be 30. Thus each group will have a sample of 10.

2.5 Exclusion Criteria

- Lower premolar with dental anomalies
- Lower premolar with Resorption
- Lower premolar with internal calcification.
- Lower premolar with multiple canal.

- Materials
 - a) 30 freshly Extracted Mandibular Premolar for orthodontic purpose
 - b) Ethylene diamine tetraacetic acid (EDTA) (Prime Dental)
 - c) Sodium Hypochlorite solution (2.5% & 5.25%)
 - d) Normal saline
 - e) Protaper universal rotary file
 - f) Dentsply AH Plus sealer
 - g) Cavit(Prime Dental)
 - h) Cold cure acrylic resin
 - i) Mani Peaso reamer
 - j) Lab scanner
 - k) CAD/CAM
 - l) Polyether ether ketone post
 - m) Calibra Self adhesive luting cement
 - n) Universal testing machine
 - o) Stereomicroscope

2.6 Procedure

Step 1: Access cavity preparation with round bur (BR 45) will be done. Working length will be determined with #10K file and working length radiograph will be taken using digital RVG. Root canals will be prepared till the working length till F2 gold Protaper. Monojet syringe having a 27 gauge side vented needle will be used to irrigate prepared canal with 2 ml 5.25% NaOCl and Saline between each file during whole preparation procedure and paper point will be used to dry the canal at the end. The root canals that is prepared will be obturated using "ProTaper gutta-percha cones" & sealer (AH Plus). Temporary restorative material (Cavit) will be used to restore prepared cavity and distilled water is used to store teeth for 1 week after which sealer will be set completely. 2 layer adhesive tape will be used to cover the tooth sample which provide the space to replicate the PDL space. Vertical holding machine will be used to embed the samples in cold cure acrylic resin.

Step 2: Crown of all teeth will be decoronated at CEJ according to ferrule length using diamond disc. Peaso reamer upto no 4 will be used to prepare the post space in all the sample. Silicon stopper will be used to set the post space length

at 10 mm. Finally the post space will be irrigated with 2.5% NaOCl and normal saline and finally paper point will be used to dry the canal.

Step 3: For Post fabrication, plastic pins will be covered with auto-polymerizing pattern resin and followed by insertion within the canals. Posts will be held for a short period. They will then be removed to evaluate their fit. The post and core pattern will be scanned digitally and milled from a PEEK block. Exact post and core pattern will be produce by the CAM system. Later, the pattern kept in the sintering furnace at 1430°C in nearly 6 h and then they will be cemented using dual-cure resin cement. Surface treatment of PEEK comprised preconditioning with 50µm aluminium oxide sandblasting under 2 bar pressure.

Step 4: For the cementation, application of "37% orthophosphoric acid" (total-etch technique) within canal will be done & cleared after 30s. The transparent adhesive resin cement (calibra dual cure resin cement), base and catalyst paste will be manipulated in 1:1 ratio as guided by the producer will be used & excess spread out & this extra cement will be cleared using probe and radiation will be given 40s from all sides.

Step 5: The adhesive tape that was applied on the root surface will be taken out and the surface that is obtained in the block of acrylic in which relining will be done using "light body additional silicone impression material". As this act out the cushioning outcome of PDL, so relining is done with light body silicon. The teeth samples will be thermocycled for "10,000 cycles using distilled water at temperature in range of 5°C & 55°C".

Step 6: we then mount samples on the universal testing machine & compressive load will be given at 45° angle parallel to the tooth. We will apply the static load at a crosshead speed of 0.5 mm per min over 4 mm diameter circular tip loading jig. Fracture forces will be noted for all sample. Teeth that were fracture will be checked for failure type, cracks or fracture of core or post portion above CEJ will be considered as favorable. The failures that include dentin of the RC will be considered unfavorable. This will be done using stereomicroscope. The obtained data will be evaluated.

2.7 Statistical Analysis

Results will be subjected to statistical analysis and analysed using One way ANNOVA and post hoc Tukeys test.

2.8 Anticipated and Expected Results

Fracture resistance of teeth with 2 mm ferrule may prove better than teeth with 1 mm and no ferrule.

3. RESULTS AND DISCUSSION

Satheesh B. Haralur (2020) studied Fracture resistance of 36 root canal treated teeth in which restoration was done with various aesthetic post & divided them in three categories,

Categories A (FRC post)
Category B (PEEK post)
Categories C (PIC post).

Their results indicated that RCT teeth in which restoration was done with PEEK post showed superior fracture load (1929.94 N), trailed by "PIC post" (1810.65N), and "FRC post" (1715.68N). In the meantime, RC treated teeth restored with FRC exhibited a exclusively favorable fracture, while teeth which were restored with PEEK showed unfavorable fracture. Out of each aesthetic materials of post group, the group which included PEEK endodontic post was for which PEEK endodontic post was used displayed higher fracture resistance.

Jefferson Ricardo Pereira studied Effect of crown ferrule on fracture resistance of ETT restored with post that are prefabricated. After division of tooth in 10 groups and preparation according to 5 experimental protocols.

Control group: teeth with custom cast post and core;

Group I- 0mm group: teeth without coronal structure (no ferrule);
Group II- 1mm,
Group III- 2mm
Group IV- 3mm

Each specimens in these (non-control) groups in which restoration was done using prefabricated post (Screw-Post) & composite resin (Z100) core situated above CEJ. Test groups (control group: 818.2 N; 0-mm, 1-mm, 2-mm, and 3-mm groups: 561.0 N, 627.6 N, 745.3 N, and 907.1 N, respectively) showed significant difference ($P < 0.001$) in average fracture forces.

When the failure mode was assessed, altogether fracture of root was the cause of failures in control group, and in the 0-mm group failure

happened because of fracture of core. Crown cementation failure was the major cause of failure in most of the groups.

So, it can be concluded that, root canal treated teeth resist fracture better when there is more amount of dentin in crown.

"Merve Benli et al. (2020) studied Surface characterization and bonding properties of milled polyether ether ketone dental posts." For this study, 60 upper CI having one root were root canal treated and divided in 3 categories ($n = 20$) as the kind of post used.

Category P: PEEK,
Category F: Glass-fibre,
Category M: Cast-metal

According to the results, polyether ether ketone exhibited superior TBS & least Ra values as post compared to metal & fiberglass posts. Therefore, according to this study and low elastic modulus suggest that PEEK is a dependable post material.

Relan et al. reported about Effectiveness of Three Different Endodontic Irrigation Systems for Irrigant Delivery to Working Length of Single Rooted Teeth Using Radiopaque Dye [15].

4. CONCLUSION

The conclusion will be drawn after completion of the final experiment.

5. IMPLICATIONS

If this study proves correct, this would be helpful for the clinicians to proceed with root canal of grossly carious or traumatic tooth with loss of crown structure.

6. SCOPE

The scope of this study is to provide a method of restoring a grossly carious or fractured tooth by taking advantage of high fracture resistance of PEEK post in association with ferrule length.

7. LIMITATIONS

1. This is an in-vitro study, the possibility of clinical co-relation remains contradictory.
2. Even though each step will be performed with critical care, human error cannot be ruled out from final result.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

As per international standard or university standard, patients' written consent will be collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standard or university standard written ethical approval will be collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Faria ACL, Rodrigues RCS, de Almeida Antunes RP, de Mattos MdGC, Ribeiro RF. Endodontically treated teeth: Characteristics and considerations to restore them. *Journal of Prosthodontic Research*. 2011;55(2):69-74.
2. Khatod S, Ikhara A, Nikhade P, Chandak M, Khatod K, Jaiswal A, Chandak M, Rathi C, Motwani N. Comparative evaluation of different irrigation techniques with conventional irrigation technique for the removal of double antibiotic paste from root Canal-An *in vitro* study *International Journal of Research in Pharmaceutical Sciences*. 2020;11(4):5578-5583
3. Rathi CH, Chandak M, Nikhade P, Mankar N, Chandak M, Khatod S, Motwani N, Jaiswal A. Functions of Root Canal Sealers--A Review. *Journal of Evolution of Medical and Dental Sciences*. 2020 Apr 27;9(17):1454-9.
4. Mahapatra D, Nikhade D, Pradnya P, Sukhtankar DS. Comparative evaluation of the efficacy of light cure calcium hydroxide and theracal Ic as indirect pulp capping materials in patients with deep carious lesion-an interventional study. *European Journal of Molecular & Clinical Medicine*. 2020 Dec 22;7(7):2057-65.
5. Chandak M, Chandak M, Rathi C, Khatod S, Chandak P, Rela K. Guided Endodontics: A Novel Invasive Technique for Access Cavity preparation-Review. *International Journal of Research in Pharmaceutical Sciences*. 2020;11(3):3459-64. Available: <https://doi.org/10.26452/ijrps.v11i3.2488>
6. Bhonde R, Ikhara A, Palsodkar P. Comparative Clinical Evaluation of Post Endodontic Pain in Retreatment Cases Using Calcium Hydroxide and Triple Anti Biotic Paste an Interventional Study. *International Journal of Pharmaceutical Research*. 11:1428-30.
7. Machado J, Almeida P, Fernandes S, Marques A, Vaz M. Currently used systems of dental posts for endodontic treatment. *Procedia Structural Integrity*. 2017;5:27-33.
8. Kurtz SM, Devine JN. PEEK biomaterials in trauma, orthopaedic, and spinal implants. *Biomaterials*. 2007;28:4845-69.
9. Silthamitang P, Chaijareenont P, Tattakorn K, et al. Effect of surface pretreatments on resin composite bonding to PEEK. *Dent Mater J*. 2016;35:668-74.
10. Henriques B, Fabris D, Mesquita-Guimarães J, et al. Influence of laser structuring of PEEK, PEEK-GF30 and PEEK-CF30 surfaces on the shear bond strength to a resin cement. *J Mech Behav Biomed Mater*. 2018;84:22534.
11. Chaijareenont P, Prakhamchai S, Silthamitang P, et al. Effects of different sulfuric acid etching concentrations on PEEK surface bonding to resin composite. *Dent Mater J*. 2018;37:385-92.
12. Gutmann JL. The dentin-root complex: Anatomic and biologic considerations in restoring endodontically treated teeth. *J Prosthet Dent* 1992;67:458-67.
13. Isidor F, Brondum K, Ravnholt G. The influence of post length and crown ferrule on the resistance to cyclic loading of bovine teeth prefabricated titanium post. *Int J Prosthodont* 1999;12:78-82.
14. Sorensen JA. Preservation of tooth structure. *J Calif Dent Assoc*. 1988;16:15-22.
15. Relan K, Chandak M, Chaudhari SS. Clinical Evaluation and Comparison of

Effectiveness of Three Different Endodontic Irrigation Systems for Irrigant Delivery to Working Length of Single Rooted Teeth Using Radiopaque Dye – An Interventional Study. International Journal

of Pharmaceutical Research. 2019;11(2): 1840–43.
Available: <https://doi.org/10.31838/ijpr/2019.11.02.208>

© 2021 Taori and Nikhade; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:
<https://www.sdiarticle5.com/review-history/80052>