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Research Paper: The Fracture Resistance of Reconstructed Teeth with Three Different Post Systems (Casting Post, Pre-Fabricated Post, and Pre-Fabricated Post Modified with Amalgam) in Oval-Shaped Canals: An In Vitro Study

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ABSTRACT

Introduction: This study compared the fracture resistance and fracture pattern of endodontically treated teeth restored with three different post systems.

Materials and Methods: In this in vitro study, 30 extracted single-root human premolars with oval-shaped canals were selected. All teeth were endodontically treated and sectioned horizontally from the cement-enamel junction. Samples were randomly assigned into three groups; group 1- casting post cemented with glass-ionomer, group 2- pre-fabricated post cemented with glass-ionomer, and group 3- pre-fabricated post cemented with glass-ionomer and modified with amalgam. Fracture resistance (Newton) was measured under load on the universal load test machine. The fracture pattern was also recorded as restorable and unrestorable. The data was analyzed using SPSS version 24. ANOVA and post hoc (Tukey) were applied at the significance level of 0.05.

Results: Mean fracture resistance was 999.2±278.21 (N), 501.6±246.74 (N), and 600.23±254.04 (N) in groups 1, 2, and 3, respectively. There was no statistically significant difference in fracture resistance between groups 2 and 3. However, the fracture resistance of group 1 was significantly higher than groups 2 and 3. 100% of the failure pattern in group 1 was unrestorable. 60% and 80% of failure patterns in groups 2 and 3 were restorable, respectively.

Conclusion: Fracture resistance was higher for casting posts than for pre-fabricated posts; however, the fracture resistance of all three groups was acceptable. Using pre-fabricated posts decrease root fracture compared to casting posts. Modifying pre-fabricated posts with amalgam may minimize the occurrence of unrestorable fractures and root fracture.

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1. Introduction

The functional and aesthetic rehabilitation of teeth after root canal therapy (RCT) presents significant challenges in dentistry, as the structure and remaining tissue are often compromised (1-3). The use of posts may be necessary to ensure adequate retention for restorations in endodontically treated teeth (4,5). Posts fall into two main categories: custom-fabricated (casting) and pre-fabricated (6,7). Casting posts are typically indicated for teeth with extensive structural damage (6,8). These posts offer advantages such as tolerance to rotational forces and good adaptation to the root canal, particularly in oval-shaped canals. However, they have several drawbacks, including lack of aesthetic appeal, inability to access the root apex for retreatment if needed, and a time-consuming and expensive fabrication process (6,8-10).

Pre-fabricated posts, available in materials like stainless steel and titanium, offer several advantages, including adequate retention, affordability, and reduced treatment time (11-13). However, their success hinges on preserving sufficient dentinal tissue. While initially strong, metal posts can corrode over time, leading to cervical discoloration and an increased risk of root fracture. In contrast, pre-fabricated fiber posts, with an elastic modulus similar to dentin, are highly corrosion-resistant. Nevertheless, their failure often stems from debonding from the root structure. While casting posts offer superior fracture resistance compared to fiber posts, the resulting tooth fractures are typically more challenging to repair (14).

One of the limitations of pre-fabricated posts is their round cross-section, which hinders their adaptation to oval-shaped root canals (9-10,15). This mismatched geometry poses a challenge for optimal post placement and stability. Previous studies have explored various approaches to address this issue, including casting posts, accessory posts adjacent to the main post, and amalgam chamber pins (16-22).

In light of these challenges, the present study aimed to investigate an alternative solution: utilizing amalgam to fill the space surrounding a pre-fabricated post in oval-shaped root canals. This technique was hypothesized to enhance the adaptation of the post to the canal walls and influence its fracture resistance. A null hypothesis was formulated to test this hypothesis, stating that the fracture resistance of three different post systems (casting posts, pre-fabricated posts, and amalgam-modified pre-fabricated posts) would be similar.

2. Materials and Methods

In this in vitro study, 30 extracted maxillary premolars were assessed. The maxillary premolars were included if they were intact, had one root canal, oval root morphology, 21 mm long, 7-8 mm buccopalatally, and 5-6 mm mesiodistally, and had 14 mm root (measured by a caliper). Teeth were excluded from the study if there was hypoplasia or cracks (assessed by a microscope under ×2 magnificence) and if the thickness of the remaining dentin around the post space was less than 1.5 mm. Stain, calculus, and debris were removed using scaling and root planing from the selected teeth. The samples were stored in distilled water at room temperature during the study.

To minimize errors during access cavity preparation, all selected teeth were cut from the cement-enamel junction (CEJ) using a cylindrical diamond bur and a high-speed handpiece with water as the coolant. The working length of all teeth was determined using a #15 K-file (K-file, DiaDent, Seoul, Korea) and periapical radiography. The circumferential filing was performed up to 0.5 mm shorter than the working length. The cleaning was conducted up to K-file #30 (K-file, DiaDent, Seoul, Korea), and then shaping was carried out up to K-file #60 (K-file, DiaDent, Seoul, Korea) using the step-back technique. The root canals were dried using a paper cone (Meta BioMed Co., Ltd, Cheongju city, Chungbuk, Korea) and obturated using gutta-percha #30 (Meta BioMed Co., Ltd, Cheongju city, Chungbuk, Korea) as the master apical cone (MAC), gutta-percha #15 (Meta BioMed Co., Ltd, Cheongju city, Chungbuk, Korea) as the accessory cones and sealer (Fill Canal Grossman's sealer formulation (Dermo Laboratorios, Rio de Janeiro, Brazi) by lateral condensation technique. The gutta-percha was cut using a heat carrier at 1 mm apically to CEJ.

Following the RCT, the teeth were randomly assigned to three groups. Group 1 was restored using casting post and glass-ionomer luting cement (GC Corporation Tokyo, Japan). Groups 2 and 3 were restored using pre-fabricated stainless steel post (Reforpost stainless steel, Angelus, Londrina, PR, Brazil) and glass-ionomer luting cement (GC Corporation Tokyo, Japan); group 3 amalgam was packed in the space around the post.

The post space was prepared in all samples using Peeso-reamer #1, #2, and #3 (Mani, Utsunomiya, Japan). 10 mm of gutta-percha was removed from the root canals so that 3 to 5 mm of gutta-percha remained at the apical portion of root canals. For group 1, 12 mm casting posts were fabricated. For Group 2 and 3, pre-fabricated posts (Large, diameter 1.35 mm, length 12 mm, #3) (Reforpost stainless steel, Angelus, Londrina, PR, Brazil) were selected.

To cement the posts for groups 1 and 2, the post space was filled with glass-ionomer luting cement (GC Corporation Tokyo, Japan) using Lentulo #30 (Paste Carrier, Medin, Czech Republic). The casting posts in group 1 and the pre-fabricated posts in group 2 were placed in the root canal and kept immobilized for 10 seconds. The residual cement was removed using an explorer.

To cement the posts for group 3, the apical two-thirds portion of post space was filled with glass-ionomer luting cement (GC Corporation Tokyo, Japan) using Lentulo #30 (Paste Carrier, Medin, Czech Republic). The pre-fabricated posts were placed in the root canal and immobilized for 10 seconds. Once the cement had set, the coronal one-third portion of post space was filled with amalgam (Sinalux, Faghihi, Iran) using a hand plugger (Dena, Pakistan) to pack it.

The roots were covered with 0.2 mm-thick aluminum foil from the apex to 2 mm apical to CEJ to simulate the periodontium. Subsequently, the samples were mounted in acrylic molds (using Acropars acrylic resins, Marlic Co., Tehran, Iran) 2 mm apical to CEJ in order to align the occlusal surface parallel to the horizontal plane. The acrylic mold was then placed in a jig at a 45-degree angle. Upon the appearance of polymerization signs, the tooth was gently extracted from the acrylic mold with a circular motion, and the aluminum foil was removed from the roots. Then a polyether material (Impregum, 3M ESPE, USA) was injected into the acrylic mold, and the tooth (without aluminum foil) was again placed in the mold. The residual polyether material was removed by a blade. This way, the artificial periodontal ligament was simulated.

Fracture resistance (Newton) was measured under load on the universal load test machine. For all specimens, the compressive load was applied to the head of the post's palatal side by using a round-ended compressive head.

The force was applied to the samples at a 45-degree angle to simulate the masticatory forces in the oral environment with a 1 mm/min speed until fracture.

A fracture pattern was also recorded. If the fracture was in the coronal of the acrylic resin block or the post was fractured, the fracture pattern was considered restorable. If the fracture was in the apical of the acrylic resin block, or if the root was fractured vertically or horizontally, the fracture was reported as unrestorable (23).

The data was analyzed using SPSS version 24 (IBM Corp, Armonk, NY, USA). ANOVA and post hoc (Tukey) were applied at the significance level of 0.05.

3. Results

Fracture resistance was measured in all three study groups. (Table 1) According to ANOVA, the fracture resistance was significantly higher in group 1 compared to groups 2 and 3. (P<0.001).

According to Post Hoc Tukey, the fracture resistance was significantly higher in group 1 than in groups 2 and 3 (P=0.001, and P=0.005, respectively). However, the fracture resistance was not significantly different between group 2 and group 3. (P=0.677). All study groups reported a fracture pattern (restorable and unrestorable) (Table 2).

Table 1. Fracture resistance in three study groups.

Study groups	Sample size	Mean and Standard deviation (N)	P-value
Group 1	10	999.2 ± 278.21	<0.001
Group 2	10	501.65 ± 246.74	
Group 3	10	600.23 ± 254.04	

Table 2. Fracture pattern in three study groups.

Study groups	Restorable			Unrestorable			
	above acrylic resin block	Post fracture	Total	Vertical root fracture	Horizontal root fracture	below acrylic resin block	Total
Group 1	0% (0)	0% (0)	0% (0)	50% (5)	40% (4)	10% (1)	100% (10)
Group 2	40% (4)	20% (2)	60% (6)	30% (3)	10% (1)	0% (0)	40% (4)
Group 3	30% (3)	50% (5)	80% (8)	20% (2)	0% (0)	0% (0)	20% (2)

4. Discussion

Following root canal therapy (RCT), the fracture resistance of teeth decreases due to the loss of dental structure caused by decay, trauma, or access cavity preparation. (6-7) Consequently, the success of RCT heavily relies on the restoration and reconstruction of the remaining tooth structure. The survival of this restoration, in turn, depends on several factors: the presence of a ferrule, the shape and type of post, the post's anti-rotational properties, and its adaptation to the root canal. (1,2,8) Various methods, such as casting posts or accessory posts adjacent to the main post, have been suggested to improve this adaptation in canals with unique morphologies. (16-22) This study aimed to investigate whether using amalgam to fill the space around a pre-fabricated post could effectively enhance its adaptation to oval root canals and influence fracture resistance. In this study, the mean fracture resistance for premolars restored with casting posts (group 1) was 999.2 N, significantly higher than the 501.65 N and 600.23 N observed for pre-fabricated posts (group 2) and amalgam-modified pre-fabricated posts (group 3), respectively. However, there was no significant difference in fracture resistance between the two types of pre-fabricated posts.

These findings align with those of Solanki et al. (17) and Ignatious et al. (18), who also reported that casting posts exhibited greater resistance to vertical and horizontal forces compared to pre-fabricated fiber posts. Darabi et al. (19) similarly found that casting posts demonstrated notably higher fracture resistance than carbon fiber posts and composite cores. Moreover, Elavarasu et al. (20) and Fadag et al. (10) support the results of the current study, showing superior fracture resistance for casting posts compared to pre-fabricated and carbon fiber posts.

Conversely, Sonkesriya et al. (21) reported no significant difference in fracture resistance among pre-fabricated, casting, and carbon fiber posts. This discrepancy may be attributed to differences in tooth selection between studies. Sonkesriya et al. (21) used maxillary incisors, while the current study utilized maxillary premolars.

Maalhagh-Fard et al. (22) assessed the fracture resistance of posts and cores and stated that there are some principles to fabricating posts and cores with proper function: preserving the tooth structure as much as possible, not using posts to reinforce the tooth structure and evaluating whether there is any parafunction. In this study, the fractures caused by casting posts (group 1) were all unrestorable, while the pre-fabricated posts (groups 2 and 3) caused unrestorable fractures less frequently. Also, the results showed that the frequency of unrestorable fractures was less when the pre-fabricated posts were modified with amalgam (group 3). According to Kurthukoti et al. (24) and Fadag et al. (10), failures caused by casting posts are focused on the tooth structure, and their damage is not restorable. Their finding confirms the results of the current study.

Multiple studies have examined the fracture resistance of different post and core systems and have reported contrary results. This divergence in findings may be due to differences in methodology, physical and chemical properties of used materials, root canal morphology, and biochemical combination of human extracted teeth. In the current study, the crown of teeth was cut to simulate the teeth that had lost their coronal sections due to trauma or caries; therefore, it was not possible to assess the ferrule effect in this study. Based on the results, when there is no ferrule, the force mainly focuses on the border between the post and core; hence, the post can easily break and fall out. However, this study aims to compare the technique of using a prefabricated metal post and amalgam in the space surrounding the post with conventional techniques without relying on the ferrule effect. This would allow for precise comparison of the fracture resistance of oval-shaped root canals restored with these three methods.

Another limitation of this study was the potential interference of pre-fabricated post threads with amalgam packing and the narrow space between the post and tooth, contributing to the presence of voids and inadequate compaction of amalgam and its mechanical properties. A possible avenue for future investigation involves removing the threads of pre-fabricated posts and then compacting the amalgam.

5. Conclusion

Considering the limitations of this study, it can be concluded that;

1- The fracture resistance of single root premolars after RCT is significantly different when rehabilitated with casting or pre-fabricated posts. So that the casting posts showed higher fracture resistance compared to pre-fabricated posts.

2- The fracture mode was different in single root premolars depending on the type of post and luting agent.

3- Using pre-fabricated posts decrease root fracture compared to casting posts.

4- Modifying pre-fabricated posts with amalgam may minimize unrestorable fractures and reduce the incidence of root fractures.

Ethical Considerations

This study was approved by the Ethics Committee of Guilan University of Medical Sciences (IR.GUMS.REC.1396.157).

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None.

Authors' Contributions

Reza Tayefeh Davalloo: Conceptualization, Methodology, Writing - Review & Editing **Emad Pourhassan**: Writing - Original Draft, Data Curation, Supervision **Javid Janeshin**: Resources, Investigation, Visualization **Farideh Darabi**: Writing - Review & Editing, Investigation **Maryam Tavangar**: Writing - Original Draft, Visualization

Conflict of Interests

The authors declare no conflict of interest.

Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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References

1. Lee JD, Khan M, Lee SJ. A Prosthetically Guided Technique for Cast Post-and-Core Fabrication. Compendium. 2021;42(9) :512-15. [PMID]
2. Mannocci F, Bhuva B, Roig M, Zarow M, Bitter K. European Society of Endodontology position statement: The restoration of root filled teeth. Int Endod J. 2021;54(11):1974-81. [DOI: 10.1111/iej.13607] [PMID]
3. Usta SN, Cömert-Pak B, Karaismailoğlu E, Eymirli A, Deniz-Sungur D. Patterns of Post-Endodontic Restoration: A Nationwide Survey of Dentists in Turkey. Int J Environ Res Public Health. 2022;19(3):1794. [DOI: 10.3390/ijerph19031794] [PMID] [PMCID]
4. Thanish Ahamed S, Ranjan DM, Mathew DM. Association of Age and Gender to Custom Made Cast Post Given as Post Endodontic Restoration. Int J Dentistry Oral Sci. 2021;8(8):3945-8. [DOI: 10.19070/2377-8075-21000807]
5. Fornari BS, Solda C, Dotto L, Rigo L. Factors associated with decision-making of replacing the temporary coronal restoration after endodontic treatment. Braz J Oral Sci. 2022;21:e225580. [DOI: 10.20396/bjos.v21i00.8665580]
6. Sarkis-Onofre R, Pinheiro HA, Poletto-Neto V, Bergoli CD, Cenci MS, Pereira-Cenci T. Randomized controlled trial comparing glass fiber posts and cast metal posts. J Dent. 2020;96:103334. [DOI: 10.1016/j.jdent.2020.103334] [PMID]
7. Haralur SB, Al Ahmari MA, AlQarni SA, Althobati MK. The effect of intraradicular multiple fiber and cast posts on the fracture resistance of endodontically treated teeth with wide root canals. Biomed Res Int. 2018;2018:1671498. [DOI: 10.1155/2018/1671498] [PMID] [PMCID]
8. Pomini MC, Machado MM, de Paula Quadros G, Gomes GM, Pinheiro LO, Samra AP. In vitro fracture resistance and bond strength of self-adhesively luted cast metal and fiber-reinforced composite posts and cores: Influence of ferrule and storage time. Int J Prosthodont. 2019;32(2):205-7. [DOI: 10.11607/ijp.5956] [PMID]
9. Martins MD, Junqueira RB, de Carvalho RF, Lacerda MF, Faé DS, Lemos CA. Is a fiber post better than a metal post for the restoration of endodontically treated teeth? A systematic review and meta-analysis. J Dent. 2021;112:103750. [DOI: 10.1016/j.jdent.2021.103750] [PMID]
10. Fadag A, Negm M, Samran A, Samran A, Ahmed G, Alqerban A, Özcan M. Fracture resistance of endodontically treated anterior teeth restored with different post systems: An *in vitro* study. European Endodontic Journal. 2018;3(3):174-8. [DOI: 10.14744/eej.2018.70299] [PMID] [PMCID]
11. Ruttonji ZR, Kusugal PB, Nayak A, Mahajan D, Sushma KM, Patil VN. Comparative evaluation of the effect of surface treatment of fiber-reinforced posts and pre-fabricated metal posts on adhesion of a resin-based luting cement: An *in vitro* study. J Conserv Dent. 2019;22(3):245-48. [DOI: 10.4103/JCD.JCD_402_18] [PMID] [PMCID]
12. Wang X, Shu X, Zhang Y, Yang B, Jian Y, Zhao K. Evaluation of fiber posts vs metal posts for restoring severely damaged endodontically treated teeth: a systematic review and meta-analysis. Quintessence Int. 2019;50(1):8-20. [DOI: 10.3290/j.qi.a41499] [PMID]
13. Keerthana T, Mahalakshmi J, Deepak S. Comparative Analysis of Different Sizes of Prefabricated Metal Posts Placed in Relation to Premolars-A Retrospective Analysis. Indian Journal of Forensic Medicine & Toxicology. 2020;14(4). [DOI:10.37506/ijfmt.v14i4.12385]
14. Monticelli F, Osorio R, Sadek FT, Radovic I, Toledano M, Ferrari M. Surface treatments for improving bond strength to prefabricated fiber posts: a literature review. Oper Dent. 2008;33(3):346-55. [DOI: 10.2341/07-86] [PMID]
15. Satija R, Singla MG. Customizing the pre-fabricated fiber post: A case report. IP Indian Journal of Conservative and Endodontics. 2021;6(3):176-80. [DOI:10.18231/j.ijce.2021.038]
16. Ferrario V.F , Sforza C ,Serrao G ,Dellavia C , G.M Tartaglia G.M. Single tooth bite forces in healthy young adults. J Oral Rehabil. 2004;31(1):18-22. [DOI: 10.1046/j.0305-182x.2003.01179.x] [PMID]
17. Solanki N, Kishan KV, Saklecha P, Parikh M. Comparison of fiber-reinforced composite and nanohybrid resin impregnated with glass fibers as postendodontic restoration in molars–A clinical study. J Conserv Dent. 2021;24(5):514-18. [DOI: 10.4103/jcd.jcd_147_21] [PMID] [PMCID]
18. Ignatious V, Saldanha S, Rodrigues S, Pai U, Hegde P. Comparison and Evaluation of Fracture Resistance of Endodontically Treated Maxillary Central Incisors with 3 Different Bonded Post and Cores: An In Vitro Study. Indian Journal of Forensic Medicine & Toxicology. 2019;13(4). [DOI: 10.5958/0973-9130.2019.00302.5]
19. Darabi F, Namazi L. A Comparison of the Fracture Resistance of Endodontically Treated Teeth Using Two Different Restoration Systems. Dent Res J. 2009;5(2). [Link]
20. Elavarasu P, Karumaran CS, Indira R, Anilkumar R, Mani R, Natarajan R. An *in vitro* evaluation of fracture resistance of endodontically treated maxillary central incisor restored with custom-made cast post and core with uniform and nonuniform core ferrule heights. J Pharm Bioallied Sci. 2019;11(Suppl 2):S407. [DOI: 10.4103/JPBS.JPBS_50_19]
21. Sonkesriya S, Olekar ST, Saravanan V, Somasunderam P, Chauhan RS, Chaurasia VR. An *In Vitro* Comparative Evaluation of Fracture Resistance of Custom Made, Metal, Glass Fiber Reinforced and Carbon Reinforced Posts in Endodontically Treated Teeth. J Int Oral Health. 2015;7(5):53-5. [PMID] [PMCID]
22. Maalhagh-Fard A, Pacheco RR, Gill K, Wagner WC. Effects of ferrule and diameter of parallel cast post and core on fracture resistance. Brazilian Dent Sci. 2019;22(4):538-45. [DOI: 10.14295/bds.2019.v22i4.1720]

23. Abdulrazzak SS, Sulaiman E, Atiya BK, Jamaludin M. Effect of ferrule height and glass fibre post length on fracture resistance and failure mode of endodontically treated teeth. Aust Endod J. 2014;40(2):81-6. [DOI: 10.1111/aej.12042] [PMID]

24. Kurthukoti AJ, Paul J, Gandhi K, Rao DB. Fracture resistance of endodontically treated permanent anterior teeth restored with three different esthetic post systems: An *in vitro* study. J Indian Soc Pedod Prev Dent. 2015;33(4):296-301. [DOI: 10.4103/0970-4388.165675] [PMID]