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Comparative Evaluation Of Fracture Resistance Of Endodontically Treated Maxillary Central Incisors Restored With Different Post Systems: An In-Vitro Study

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Abstract
Aim
To evaluate and compare the fracture resistance of endodontically treated maxillary central incisors restored with different post systems including cast post, stainless steel post, compo post, and glass fiber pin post using a universal testing machine.
Materials and Methods
Eighty extracted human maxillary central incisors with fully formed apices were selected and randomly divided into five groups (n=16):
- *Group I – Control group*
- *Group II – Cast post*
- *Group III – Stainless steel post*
- *Group IV – Compo post*
- *Group V – Glass fiber pin post*

All teeth underwent root canal treatment followed by standardized post space preparation up to 10 mm using Peeso reamers. Specimens were restored according to assigned post systems and subjected to fracture resistance testing using a universal testing machine.
Results
Cast post systems demonstrated maximum fracture resistance followed by stainless steel posts. Glass fiber pin posts exhibited lower fracture resistance values but showed favorable biomechanical behavior and reparable fracture patterns. Compo posts demonstrated intermediate performance.
Conclusion
Rigid post systems exhibited superior fracture resistance; however, fiber-based posts demonstrated more favorable stress distribution and biomechanical compatibility with dentin, suggesting improved clinical prognosis.
Keywords: *Fracture resistance, Cast post, Stainless steel post, Glass fiber post, Endodontically treated teeth, Post-endodontic restoration.*

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I. Introduction

Endodontically treated teeth frequently exhibit increased susceptibility to fracture due to loss of tooth structure resulting from caries, access preparation, instrumentation, and restorative procedures. Structural loss rather than endodontic treatment itself is considered the principal factor responsible for biomechanical weakening.

Posts are indicated when insufficient coronal structure remains for retention of core restorations. However, posts do not reinforce teeth; instead, they primarily serve to retain the core. Preservation of remaining dentin is therefore essential in post-endodontic restoration.

Conventional cast metal posts have been extensively used because of excellent strength and adaptation. However, their high modulus of elasticity often causes stress concentration within dentin leading to catastrophic fractures. Fiber-reinforced posts have emerged as alternatives because their elastic modulus approximates dentin, improving stress distribution and reducing root fracture risk.

The concept of preservation of pericervical dentin has further emphasized the importance of minimally invasive restorative approaches.

Therefore, this study was undertaken to compare fracture resistance of endodontically treated teeth restored with different post systems.

II. Aim And Objectives

Aim

To compare fracture resistance of endodontically treated maxillary central incisors restored with different post systems.

Objectives

1. To evaluate fracture resistance of cast post restorations.
2. To evaluate fracture resistance of stainless steel posts.
3. To assess performance of compo posts.
4. To evaluate fracture resistance of glass fiber pin posts.
5. To compare fracture behavior among different post systems.

III. Materials And Methodology

The study was conducted in the Department of Conservative Dentistry and Endodontics, Jaipur Dental College (MVGU), Jaipur in collaboration with ITS Dental College, Greater Noida.

Sample Selection

Eighty extracted human maxillary central incisors with fully formed apices were selected. Teeth were stored in normal saline at room temperature to avoid dehydration.

Inclusion Criteria

- Maxillary central incisors
- Fully formed apices

Exclusion Criteria

- Internal resorption
- External resorption
- Root caries
- Cracks
- Calcified canals
- Incomplete root formation

Group Distribution

Group	Restorative System	Sample Size
Group I	Control	16
Group II	Cast post	16
Group III	Stainless steel post	16
Group IV	Compo post	16
Group V	Glass fiber pin post	16

Sample Preparation

Root Canal Treatment Procedure

Access cavity preparation was performed using round bur and Endo-Z bur. Canal patency was established with size-10 K-file and working length was determined radiographically.

Biomechanical preparation was completed using step-back technique to master apical file size 40 and enlarged up to file size 55.

Irrigation protocol:

- 2.5% Sodium hypochlorite during instrumentation
- 17% EDTA as final rinse

- Normal saline flush

Obturation was performed using lateral condensation technique with Sealapex sealer and gutta-percha size 40.

Group I – Control

Access cavities were restored with light cure composite and crown preparation standardized to 8 mm from incisal edge to cervical region.

Group II – Cast Post

Direct wax pattern fabrication was performed and cast using Ni-Cr alloy via lost wax technique.
Post surface treatment:
- Sandblasting with 50 µm aluminum oxide
- Distilled water cleaning
- Cementation with glass ionomer cement

Group III – Stainless Steel Post

Post space was prepared to match stainless steel post dimensions.
Composite core build-up was performed using incremental curing technique.

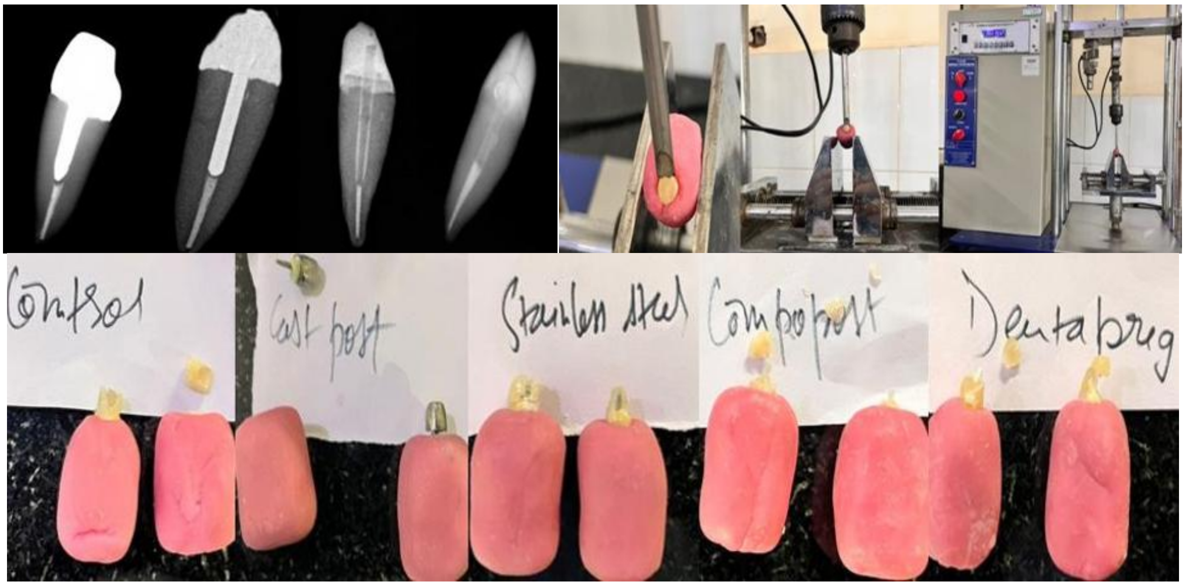
Group IV – Compo Post

Prefabricated fiber post was coated with hybrid composite and adapted to canal anatomy.
Post polymerization:
- Initial curing: 10 seconds
- Additional curing: 20 seconds

Final cementation was done using dual cure adhesive resin cement.

Group V – Glass Fiber Pin Post

Glass fiber pin posts were shortened to standardized dimensions and cemented after post space treatment. Total post length was maintained at approximately 15 mm.



IV. Results

Table 1. Comparison of Fracture Resistance Among Experimental Groups

Group	Post System	Fracture Resistance Trend
Group I	Control	Baseline
Group II	Cast post	Highest
Group III	Stainless steel post	High
Group IV	Compo post	Moderate
Group V	Glass fiber pin post	Lower

Overall trend: **Cast Post > Stainless Steel > Compo Post > Glass Fiber Post**

Table 2. Fracture Pattern Analysis

Post System	Fracture Pattern	Restorability
Cast post	Root fracture	Mostly non-restorable
Stainless steel	Unfavorable root fracture	Limited restorability
Compo post	Mixed failure	Intermediate
Glass fiber	Coronal/post debonding	Favorable

Table 3. Biomechanical Characteristics

Post Type	Modulus Compatibility	Stress Distribution
Cast post	Low	High stress concentration
Stainless steel	Low	Concentrated stress
Compo post	Moderate	Better distribution
Glass fiber	Similar to dentin	Uniform distribution

V. Discussion

Restoration of endodontically treated teeth remains a significant challenge because these teeth frequently exhibit compromised structural integrity following caries removal, access cavity preparation, biomechanical instrumentation, and restorative procedures. Traditionally, endodontically treated teeth were considered brittle due to dehydration and altered dentin properties. However, studies by **Helfer et al.** and **Sedgley et al.** demonstrated that dentin moisture content and mechanical properties remain relatively unchanged after endodontic therapy and that increased fracture susceptibility is mainly attributed to structural loss rather than intrinsic changes in dentin.

In the present study, **cast post systems exhibited the highest fracture resistance** among all experimental groups. The superior performance observed with cast posts may be attributed to their custom adaptation to root canal anatomy and greater rigidity, which enhances retention and load-bearing capacity. Similar findings were reported by **Alharbi et al.**, **Belli et al.**, and **Fadag et al.**, who observed that metallic post systems demonstrate greater fracture resistance because of higher elastic modulus and rigidity.

Despite superior fracture strength, cast posts frequently resulted in **unfavorable fracture patterns**, usually extending into the root and rendering teeth non-restorable. This behavior can be explained by the difference between elastic modulus of metallic posts and dentin. Metallic posts transmit functional stresses directly to radicular dentin, creating stress concentration zones especially at cervical and apical regions. Finite element analysis performed by **Pierrisnard et al.** demonstrated that rigid posts generate high tensile stresses at the post–dentin interface and cervical root areas, increasing the probability of catastrophic failure.

The **stainless-steel post group** demonstrated fracture resistance values lower than cast posts but higher than fiber-based systems. The higher strength observed in this group may similarly be explained by increased rigidity and resistance to deformation. However, fracture patterns remained predominantly unfavorable because stainless steel exhibits modulus mismatch with dentin, causing stress concentration within root structure. Earlier photoelastic investigations by **Assif et al.** demonstrated that metallic posts produce stress concentration at cervical and apical root areas, which predisposes teeth to root fracture.

The **compo post group** demonstrated intermediate fracture resistance values. The improved performance of compo posts compared with conventional rigid systems may be attributed to anatomical adaptation and adhesive bonding. In the present study, prefabricated fiber posts were customized with composite resin prior to cementation, producing improved adaptation and reducing cement thickness. This observation agrees with findings of **Grandini et al.** and **Monticelli et al.**, who reported that anatomic posts improve adaptation, minimize void formation, reduce polymerization shrinkage stress, and improve retention.

The **glass fiber post group demonstrated lower fracture resistance values** compared with metallic systems; however, it exhibited **more favorable and repairable failure patterns**. Most failures were limited to post debonding, core fracture, or coronal fractures, preserving radicular dentin and improving retreatability. Similar findings have consistently been reported by **Akkayan and Gülmez**, **Barjau-Escribano et al.**, **Newman et al.**, and **Ferrari et al.**, who concluded that fiber posts provide more favorable fracture behavior despite slightly lower strength values.

The improved biomechanical behavior of fiber posts is largely attributed to their **modulus of elasticity closely resembling dentin**. This dentin-like flexibility allows homogeneous stress distribution and minimizes concentration of forces within root dentin. The findings of the present study correlate with investigations by **Plotino et al.**, **Ferrari et al.**, and **Martínez-Insua et al.**, who emphasized that fiber posts improve stress distribution and reduce catastrophic root fractures.

Another important factor influencing fracture resistance is the **ferrule effect**. Previous studies by **Tan et al.**, **Zicari et al.**, and **Libman et al.** demonstrated that preservation of 1–2 mm coronal dentin significantly increases fracture resistance irrespective of post type used. The ferrule redistributes stresses away from the post–dentin interface and reduces root fracture incidence.

Modern restorative concepts also emphasize preservation of **pericervical dentin (PCD)**. **Clark et al.** described PCD as dentin extending approximately 4 mm above and below alveolar crest level and identified it as the structural core of the tooth responsible for resisting functional loading. Excessive removal of dentin during post preparation weakens this region and compromises long-term prognosis.

The present findings therefore support the concept that **higher fracture resistance does not necessarily indicate superior clinical performance**. Although cast and stainless-steel posts demonstrated greater load-bearing capacity, they frequently resulted in non-restorable fractures. Conversely, fiber posts exhibited lower fracture resistance but provided favorable stress distribution and repairable failure modes.

These findings are consistent with the contemporary philosophy of **minimally invasive endodontics**, where preservation of dentin and biomechanical compatibility are considered more important than absolute material strength. Therefore, selection of post systems should be based not only on fracture resistance but also on stress distribution characteristics, failure patterns, ferrule presence, and remaining tooth structure.

Within the limitations of this in-vitro study, **glass fiber posts demonstrated superior biomechanical behavior**, while **cast posts demonstrated maximum fracture resistance**. Hence, fiber posts may provide improved long-term prognosis because of their dentin-like properties and favorable failure characteristics.

VI. Conclusion

Within the limitations of this *in vitro* study, cast post systems demonstrated the highest fracture resistance, while stainless steel posts also exhibited high fracture resistance but were associated with unfavorable, non-restorable fracture patterns. Although glass fiber posts showed comparatively lower fracture resistance, they resulted in more favorable and restorable failures. Owing to their elastic modulus being similar to that of dentin, fiber posts provided superior biomechanical compatibility and more uniform stress distribution. Overall, preservation of the remaining tooth structure remains the most critical determinant of the long-term clinical success of endodontically treated teeth, irrespective of the post system used.

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