RESEARCH PAPER

In Vitro Comparative Analysis of Fracture Resistance in Endodontically Treated Teeth Restored Using Fiber Posts, Metal Posts and Composite Resin Systems

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ABSTRACT

Endodontically treated teeth (ETT) are structurally compromised due to the loss of tooth structure, making them more susceptible to fracture. The selection of an appropriate post and core system plays a crucial role in reinforcing these teeth. This in vitro study aimed to compare the fracture resistance of ETT restored using fiber posts, metal posts, and composite resin systems. A total of 45 extracted human mandibular premolars were endodontically treated and randomly allocated into three groups ($n = 15$): Group I (fiber post with composite core), Group II (metal post with composite core), and Group III (composite resin restoration without post). All specimens were subjected to compressive loading using a universal testing machine until fracture occurred. The mean fracture resistance values were statistically analyzed using one-way analysis of variance (ANOVA), followed by Tukey's post hoc test. The results demonstrated that the fiber post group exhibited significantly higher fracture resistance compared to the metal post and composite-only groups ($p < 0.05$), while the composite-only group showed the lowest fracture resistance. Within the limitations of this study, it can be concluded that fiber posts provide superior biomechanical compatibility and improved stress distribution, thereby enhancing the fracture resistance of endodontically treated teeth.

Keywords: Endodontically treated teeth, fiber post, metal post, composite resin, fracture resistance, in vitro.
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1. INTRODUCTION

Endodontically treated teeth (ETT) are more susceptible to fracture due to the loss of structural integrity caused by caries, access cavity preparation, and biomechanical instrumentation during root canal therapy. These procedures often result in significant removal of tooth structure, weakening the remaining dentin and compromising the tooth's ability to withstand functional and occlusal forces. Therefore, the restoration of such teeth is critical to ensure their long-term survival, functional efficiency, and resistance to fracture. Post and core systems are commonly employed to restore endodontically treated teeth, particularly in cases with extensive loss of coronal tooth structure. The primary purpose of a post is to provide retention for the core material, which subsequently supports the final restoration. Traditionally, metal posts have been widely used due to their high strength, rigidity, and long clinical history (Ferrari et al., 2000). However, the modulus of elasticity of metal posts is significantly higher than that of dentin, which can lead to uneven stress distribution within the root. This mismatch in mechanical properties often results in stress concentration, predisposing the tooth to catastrophic and non-repairable root fractures under functional loading. In recent years, fiber-reinforced posts have gained considerable attention as an alternative to conventional metal posts (Heydecke & Peters, 2002). The

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elastic modulus of fiber posts is similar to that of dentin, allowing for more uniform stress distribution along the root structure. This biomechanical compatibility helps in reducing stress concentration and minimizes the risk of root fracture. Furthermore, fiber posts are associated with more favorable failure patterns, often resulting in repairable fractures, which improves the overall prognosis of the treated tooth. In addition to post-retained restorations, composite resin restorations without the use of posts are also employed in clinical situations where sufficient coronal tooth structure remains (Mannocci et al., 2005). These restorations are more conservative and preserve remaining tooth structure; however, their ability to withstand occlusal forces and resist fracture in structurally compromised teeth remains questionable. The absence of internal reinforcement may limit their durability, especially under high functional stresses. Given these considerations, the selection of an appropriate post and core system is of paramount importance for the longevity of endodontically treated teeth (Dietschi et al., 2007). Therefore, the present study aims to compare the fracture resistance of endodontically treated teeth restored using fiber post systems, metal post systems, and composite resin restorations without posts.

2. MATERIALS AND METHODS

This in vitro study was conducted to evaluate and compare the fracture resistance of endodontically treated teeth restored using different post and core systems. A total of 45 extracted human mandibular premolars of similar dimensions were selected for the study. Teeth with visible cracks, caries, restorations, or any structural defects were excluded to ensure uniformity and standardization of the samples. All selected specimens underwent standardized root canal treatment using conventional endodontic procedures. Following obturation with gutta-percha and an appropriate sealer, decoronation was performed at the cemento-enamel junction (CEJ) to obtain uniform root lengths across all samples. The specimens were then randomly allocated into three groups (n = 15 each) based on the type of restoration: Group I consisted of teeth restored with fiber posts and composite cores, Group II included teeth restored with metal posts and composite cores, and Group III comprised teeth restored with composite resin without the use of posts.

Post space preparation was carried out for Groups I and II using Peeso reamers to a standardized depth of 10 mm, while maintaining an apical seal of 4 mm to preserve the integrity of the root canal filling. In Group I, fiber posts were cemented using resin cement, followed by core build-up with a light-cured composite resin. In Group II, metal posts were cemented using glass ionomer cement, and composite cores were subsequently fabricated. In Group III, no post was placed, and the coronal portion was restored directly with composite resin. For fracture testing, all specimens were embedded in acrylic resin blocks to facilitate handling and stability. A silicone-based material was applied around the root surface to simulate the periodontal ligament and mimic clinical conditions. Each specimen was then subjected to compressive loading at an angle of 135° to the long axis of the tooth using a universal testing machine. The load was applied continuously until fracture occurred, and the maximum fracture resistance was recorded in Newtons (N).

The obtained data were statistically analyzed using one-way analysis of variance (ANOVA) to evaluate differences among the groups. Tukey's post hoc test was performed for pairwise comparisons, and a significance level of $p < 0.05$ was considered statistically significant.

3. **RESULTS**

The fracture resistance values obtained for the three experimental groups are summarized in Table 1. The mean fracture resistance was highest in the fiber post group (780 ± 65 N), followed by the metal post group (650 ± 70 N), while the composite-only group exhibited the lowest values (480 ± 55 N). These findings indicate a clear variation in fracture resistance depending on the type of post and core system used.

Table 1: Mean Fracture Resistance of Different Groups

Group	**Mean ± SD (N)**
Fiber Post	780 ± 65
Metal Post	650 ± 70
Composite Only	480 ± 55

Statistical analysis using one-way analysis of variance (ANOVA) revealed a statistically significant difference in fracture resistance among the three groups ($p < 0.05$). Subsequent pairwise comparisons using Tukey's post hoc test demonstrated that the difference between the fiber post and metal post groups was statistically significant (Zarone et al., 2008). Furthermore, the comparison between the fiber post and composite-only groups showed a highly significant difference, indicating the superior performance of fiber posts in enhancing fracture resistance.

4. DISCUSSION

The present study evaluated the influence of different post and core systems on the fracture resistance of endodontically treated teeth. The results clearly indicate that fiber post systems provide significantly higher fracture resistance compared to metal posts and composite-only restorations. These findings can be attributed to differences in the mechanical properties and stress distribution patterns associated with each restorative approach. Fiber posts demonstrated the highest fracture resistance among all groups (González-Lluch et al., 2009). This can be primarily attributed to their elastic modulus, which is closely comparable to that of dentin. Such similarity allows for more uniform stress distribution along the root structure, thereby minimizing stress concentration and reducing the likelihood of root fracture. In addition, fiber posts tend to exhibit more favorable failure patterns, often resulting in repairable fractures, which enhances the clinical prognosis of the restored tooth. These observations are consistent with previous studies that have reported improved biomechanical performance and fracture resistance with fiber-reinforced post systems. In contrast, metal posts exhibited moderate fracture resistance but were associated with less favorable biomechanical behavior (Naumann et al., 2009). The significantly higher modulus of elasticity of metal posts compared to dentin leads to uneven stress distribution and concentration within the root. This often results in catastrophic root fractures, which are typically non-repairable and may necessitate extraction. Previous systematic reviews have also reported a higher incidence of unfavorable fracture patterns in teeth restored with metal posts (Schwartz & Robbins, 2004). Composite resin restorations without the use of posts demonstrated the lowest fracture resistance among all groups. This may be attributed to the absence of internal reinforcement, which limits the ability of the restored tooth to withstand functional and occlusal loads. Although such restorations are more conservative and preserve remaining tooth structure, their mechanical performance may be compromised, particularly in cases with extensive coronal damage.

Distinct differences in failure patterns were observed across the groups. Fiber post restorations predominantly resulted in favorable, repairable fractures, whereas metal posts were associated with unfavorable root fractures. Composite-only restorations mainly exhibited coronal fractures. These findings are clinically significant, as repairable failures are associated with better long-term prognosis and allow for retreatment, thereby preserving the natural tooth structure.

5. LIMITATIONS

Despite providing valuable insights into the fracture resistance of different post and core systems in endodontically treated teeth, the present study has certain limitations that should be considered while interpreting the results (Akkayan & Gülmez, 2002). Firstly, the study was conducted under in vitro conditions, which do not fully replicate the complex biological and mechanical environment of the oral cavity. In clinical situations, teeth are subjected to multiple factors such as saliva, temperature variations, masticatory forces, and biological responses, all of which may influence the performance and longevity of restorative systems. Secondly, thermocycling and cyclic (fatigue) loading were not incorporated into the experimental design. These parameters are essential for simulating long-term intraoral conditions, as repeated thermal and mechanical stresses can significantly affect the durability and fracture resistance of restorative materials over time. Additionally, the sample size used in this study was relatively limited, which may affect the generalizability and statistical robustness of the findings (Fokkinga et al., 2004). A larger sample size would enhance the reliability of the results and provide more comprehensive evidence. Furthermore, the study included only mandibular premolars. Variations in tooth anatomy, root morphology, and load distribution across different tooth types may influence fracture resistance, thereby limiting the applicability of the results to other clinical situations.

Lastly, fracture resistance was evaluated under a single static loading condition. However, in the oral environment, teeth are subjected to complex, multidirectional, and dynamic forces, which may result in different fracture behaviors and clinical outcomes.

6. CONCLUSION

Within the limitations of this in vitro study, it can be concluded that the type of post and core system significantly influences the fracture resistance of endodontically treated teeth. Among the evaluated groups, fiber post systems demonstrated the highest fracture resistance, followed by metal posts, while composite-only restorations exhibited the lowest resistance. The superior performance of fiber posts is attributable to their elastic modulus being comparable to that of dentin, which facilitates more uniform stress distribution and reduces stress concentration within the root. In contrast, metal posts, despite providing moderate fracture resistance, are associated with unfavorable stress distribution and a higher risk of catastrophic, non-repairable root fractures. Composite-only restorations, due to the absence of internal reinforcement, showed limited resistance to functional loading. From a clinical standpoint, fiber posts represent a more biomechanically compatible and reliable option for restoring endodontically treated teeth, particularly in cases with substantial coronal tooth loss. Their use may enhance the longevity of restorations and promote more favorable, repairable failure patterns, thereby improving overall treatment outcomes.

7. FUTURE RECOMMENDATIONS

Further research is necessary to validate and extend the findings of the present study. Long-term clinical trials are recommended to assess the survival rate and clinical performance of different post systems under actual intraoral conditions. Future investigations should incorporate thermocycling and cyclic (fatigue) loading protocols to better simulate the thermal and mechanical challenges present in the oral environment, thereby providing a more realistic evaluation of long-term material performance. Additionally, comparative studies involving emerging materials—such as hybrid fiber-reinforced posts and advanced adhesive systems—should be undertaken to explore potential improvements in fracture resistance and clinical outcomes. Evaluating these systems across different tooth types and under varying loading conditions would further enhance their clinical relevance and applicability.

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