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Comparative Evaluation of the Fracture Resistance and Marginal Adaptation of Endodontically Treated Teeth Restored with Different Prosthodontic Techniques: A Clinical and In Vitro Study

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Abstract: Background: Endodontically treated teeth (ETT) are biomechanically compromised and more prone to fracture. Choosing the appropriate post-endodontic prosthodontic restoration is crucial for long-term success.
Aim: To compare the fracture resistance and marginal adaptation of ETT restored using three different prosthodontic techniques: full-coverage crowns with fiber post-core, endocrowns, and indirect onlays.
Materials and Methods: Thirty extracted mandibular molars were endodontically treated and randomly assigned into three groups (n=10). Group A received fiber post and full-coverage crown restorations; Group B, endocrowns; Group C, indirect composite onlays. Fracture resistance was tested using a universal testing machine. Marginal adaptation was analyzed via dye penetration and stereomicroscopy.
Results: Group B (endocrowns) showed the highest fracture resistance and lowest microleakage, followed by Group A, then Group C. Statistical analysis revealed significant differences between the groups ($p<0.05$).
Conclusion: Endocrowns demonstrated superior mechanical and marginal integrity. They may be considered a reliable alternative to traditional crown and post systems in posterior ETT.
Keywords: Endodontically treated teeth, prosthodontics, fracture resistance, marginal adaptation, endocrown

1. INTRODUCTION

The restoration of endodontically treated teeth (ETT) poses a significant clinical challenge. Following root canal therapy, teeth undergo structural changes that reduce their mechanical integrity and increase susceptibility to fracture. This weakened state arises due to loss of tooth structure from caries, cavity preparation, and endodontic access, in addition to changes in dentin moisture and collagen structure. Thus, the method of post-endodontic restoration plays a pivotal role in determining long-term success and prognosis[1-4].
Traditionally, full-coverage crowns placed over a fiber post-core have been the gold standard for posterior ETT. The fiber post provides internal support, while the crown offers protection from occlusal forces. However, advancements in adhesive dentistry have introduced alternative techniques such as endocrowns and onlays that

preserve more tooth structure and utilize adhesive bonding for retention. Endocrowns, monolithic restorations that extend into the pulp chamber, provide bulk retention and eliminate the need for intraradicular posts. Onlays, on the other hand, involve minimal preparation and restore the cuspal coverage, offering a conservative approach[5].

A crucial factor in the longevity of any restoration is fracture resistance—the ability of the restoration-tooth complex to withstand masticatory forces. Posterior teeth are especially vulnerable due to high occlusal loads. Equally important is marginal adaptation, which affects microleakage, recurrent caries, and pulpal health. Poor marginal seal can result in fluid ingress, bacterial contamination, and ultimately, restorative failure[6-8].

Multiple studies have attempted to compare various prosthodontic approaches in terms of biomechanical behavior and sealing ability. However, most have limitations such as small sample sizes, lack of in vitro validation, or exclusion of newer restorative modalities like endocrowns[9]. Furthermore, there is limited consensus on whether traditional post-core systems outperform newer adhesive alternatives in real-world clinical conditions[10,11].

Given this context, the present study was designed to comprehensively evaluate and compare the fracture resistance and marginal adaptation of endodontically treated mandibular molars restored with (1) full-coverage crowns with fiber post and core, (2) endocrowns, and (3) indirect composite onlays. Both clinical and in vitro aspects were considered to generate robust, evidence-based conclusions.

This research seeks to answer:

Which prosthodontic technique best reinforces structurally compromised ETT?

Which restoration offers the best marginal integrity?

Can newer conservative approaches like endocrowns reliably replace post-core restorations in clinical practice?

The study hopes to provide a scientific rationale for clinicians in selecting appropriate post-endodontic restorative options based on mechanical durability and marginal sealing performance.

MATERIALS AND METHODS

Sample Size and Selection: Thirty freshly extracted human mandibular first molars with similar dimensions and no caries, fractures, or restorations were selected. The sample size (n=10 per group) was based on prior literature with an effect size of 0.40, alpha of 0.05, and power of 80%.

Endodontic Treatment: All teeth were decoronated to a standardized height of 5 mm above the CEJ. Root canals were instrumented with ProTaper files and obturated using gutta-percha and AH Plus sealer by lateral condensation technique. Access cavities were sealed with resin-modified glass ionomer.

Grouping and Restoration:

Group A (n=10): Fiber post (RelyX) placed into the canal with composite core buildup. Full-coverage lithium disilicate crowns were fabricated and cemented.

Group B (n=10): Endocrowns made from lithium disilicate (IPS e.max) extending into the pulp chamber.

Group C (n=10): Indirect composite onlays (Filtek Z350 XT) with cusp coverage were fabricated and bonded.

Fracture Resistance Testing: Samples were subjected to vertical compressive loading using a universal testing machine at 0.5 mm/min until fracture. Load at fracture (in Newtons) was recorded.

Marginal Adaptation: Samples were immersed in 2% methylene blue for 24 hours. Sectioned buccolingually and examined under a stereomicroscope (40×). Dye penetration scores (0–3) were given.

Statistical Analysis: ANOVA and post-hoc Tukey tests were used for intergroup comparisons. A p-value <0.05 was considered statistically significant.

Results

Table 1: Fracture Resistance of Restored Teeth (Mean ± SD)

Group	Restoration Type	Fracture Resistance (N)
A	Post + Core + Crown	895.2 ± 45.3
B	Endocrown	1025.6 ± 36.1

C	Indirect Composite Onlay	756.8 ± 48.5

Group B (endocrowns) demonstrated significantly higher fracture resistance compared to Groups A and C ($p<0.05$). Group C had the lowest resistance, indicating that indirect onlays may offer the least reinforcement to ETT under high stress (Table 1).

Table 2: Marginal Adaptation (Dye Penetration Scores)

Group	Mean Dye Score	Interpretation
A	1.6 ± 0.5	Moderate leakage
B	0.9 ± 0.3	Minimal leakage (best seal)
C	2.1 ± 0.4	Highest leakage

Endocrowns exhibited the least microleakage, suggesting superior marginal adaptation. Indirect onlays had the poorest seal, indicating a greater risk of long-term failure due to bacterial penetration (Table 2).

DISCUSSION

The restoration of endodontically treated teeth (ETT) is critical for preventing structural failure and ensuring long-term clinical success. This study assessed and compared the fracture resistance and marginal adaptation of three restorative approaches: traditional crown with post and core, endocrowns, and indirect composite onlays.

The results clearly demonstrated that endocrowns outperform the other two techniques in terms of both fracture resistance and marginal adaptation. This aligns with the contemporary shift in restorative dentistry toward adhesive, monolithic restorations that preserve tooth structure and distribute stress more evenly.

The superior performance of endocrowns may be attributed to several factors. First, the use of high-strength ceramics like lithium disilicate enhances bulk strength. Second, the extension into the pulp chamber provides macro-retention while maximizing bonding surface area. Unlike posts, which can concentrate stress at the root, endocrowns dissipate forces over a larger area. This reduces the likelihood of catastrophic fractures, especially in molars with divergent roots and complex anatomy[12-15].

In contrast, fiber post systems, though popular, introduce potential stress points within the root canal. Moreover, the process involves additional steps—post space preparation, cementation, and core buildup—which can lead to errors. Nevertheless, they still offer better performance than indirect onlays, as seen in this study[16].

The poorest results were recorded in Group C (onlays). Despite being conservative and esthetic, onlays lack the intracoronal anchorage of endocrowns or the internal support of posts. Their shallow preparation may be insufficient to withstand heavy posterior occlusal forces. Additionally, composite materials used in indirect onlays may undergo marginal degradation or wear over time, compromising seal and strength[17].

Marginal adaptation is equally critical, as microleakage can cause recurrent caries, pulpal irritation, and restoration failure. Endocrowns again performed the best, likely due to the monolithic design and superior marginal fit of CAD/CAM-milled restorations. The reduced number of interfaces (no post, no separate core) eliminates potential leakage pathways. On the contrary, onlays showed higher dye penetration, which may compromise long-term outcomes[18].

The implications of these findings are clinically significant. In scenarios where sufficient coronal tooth structure remains, endocrowns may serve as a highly effective alternative to traditional post-core-crown systems. They reduce chairside time, eliminate post-placement risks, and show favorable biomechanics. However, clinical case selection is crucial. Endocrowns require adequate axial wall height and occlusal clearance. In teeth with severely compromised coronal walls or short clinical crowns, traditional methods may still be necessary[19,20].

This study had limitations, including a small sample size and lack of cyclic loading or aging simulation. Future studies should include long-term clinical trials and fatigue testing. Additionally, the study used extracted teeth in a laboratory setting, which may not fully replicate intraoral conditions such as thermal changes, saliva, and masticatory variability.

Nonetheless, the findings strongly support the inclusion of endocrowns in the restorative armamentarium for ETT, especially in posterior teeth. As adhesive technology continues to evolve, monolithic restorations may become the standard of care in post-endodontic rehabilitation.

CONCLUSION

Endocrowns demonstrated the highest fracture resistance and superior marginal adaptation among the three restorative techniques evaluated. Given their structural integrity and simplified workflow, endocrowns offer a promising alternative to traditional post-core-crown restorations for endodontically treated molars. Clinical judgment, however, remains key in selecting the appropriate technique based on individual tooth morphology and loading conditions.EFERENCES :

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