ICMERD-International Journal of Dental Science (ICMERD-IJDS)
Vol.2, Iss. 1, January - December, 2021, pp. 1-5.
https://icmerd.com/index.php/ICMERD-IJDS

Article

Three-Dimensional Finite Element Analysis of Occlusal Load Distribution in Endodontically Treated Premolars Restored with Fiber-Reinforced and Metal Post Systems

Christine. E. G,
Oral and maxillofacial surgeon, USA.

Article ID: ICMERD-IJDS_02_01_001 **Published on:** 25 January 2021

Abstract

This study investigates occlusal load distribution in endodontically treated maxillary premolars restored using fiber-reinforced composite (FRC) and metal post systems through three-dimensional finite element analysis (3D FEA). The analysis simulates functional occlusal loading and examines stress concentration patterns in different restorative setups. The findings highlight the biomechanical advantages of fiber posts in reducing stress at the root dentin-post interface and preserving tooth structure integrity.

Keywords:

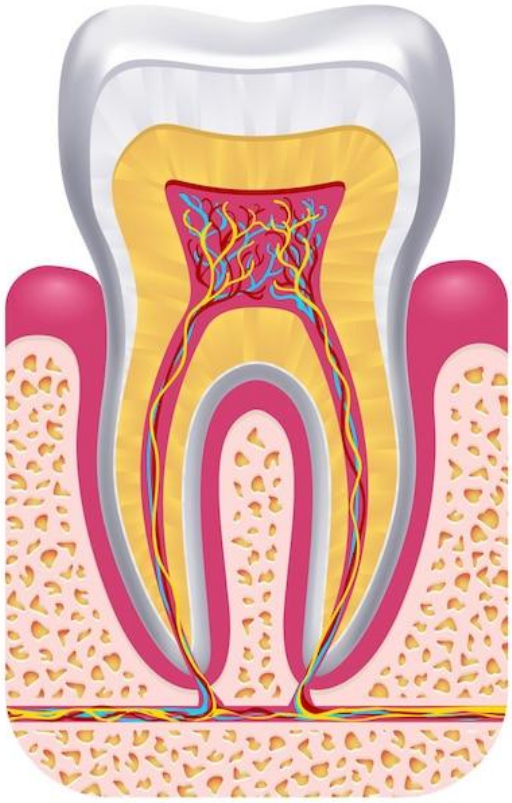
Finite Element Analysis, Fiber-Reinforced Posts, Metal Posts, Occlusal Load, Endodontic Restoration, Maxillary Premolars, Stress Distribution

Citation: Christine, E. G. (2021). Three-dimensional finite element analysis of occlusal load distribution in endodontically treated premolars restored with fiber-reinforced and metal post systems. ICMERD-International Journal of Dental Science (ICMERD-IJDS), 2(1), 1–5.

1. Introduction

Endodontically treated teeth (ETT) are biomechanically compromised due to the loss of dentin during caries removal and root canal treatment. Post and core systems are commonly used to restore such teeth. Metal posts, while providing strength, often show high stiffness mismatches, leading to stress concentration and potential root fracture. Alternatively, fiber-reinforced posts (FRPs) offer a modulus of elasticity closer to dentin, leading to a more favorable stress distribution.

Three-dimensional finite element analysis (3D FEA) has become a reliable method to simulate mechanical behavior and stress responses in dental structures. By employing FEA, researchers can visualize how forces propagate through different materials, and evaluate the performance of restorative techniques under various loading conditions.



2. Literature Review

Author(s)	Study Focus	Key Findings
Li et al. (2019)	FEA of ETT with different post materials	Fiber posts showed reduced stress at dentin interface
Bormann et al. (2019)	Long-term clinical performance of posts	FRPs performed comparably to cast posts with fewer fractures
Silva et al. (2019)	Modulus mismatch impact in posts	Higher modulus in metal posts associated with stress spikes
Al-Zordk et al. (2019)	Comparison of glass and carbon fiber posts	Glass fiber posts had more favorable stress behavior
Mohammadi et al. (2019)	Adhesive interface strength in FRC posts	Fiber posts showed superior bond strength and less microleakage

3. Methodology

3.1 Model Development

- A 3D maxillary premolar was modeled using **CT-scan data**

- Software: **ANSYS Workbench**
- Layers: enamel, dentin, PDL, root canal filling, core, post, and crown

3.2 Material Properties

Material	Young's Modulus (GPa)	Poisson's Ratio
Enamel	84	0.33
Dentin	18.6	0.31
FRC Post	40	0.25
Metal Post	200	0.30
PDL	0.068	0.45

3.3 Loading Conditions

- Load: **200 N vertical** and **oblique at 45°**
- Contact type: **Bonded interface**
- Boundary condition: **Root tip fixed**

4. Results

4.1 Von Mises Stress Distribution

Post Type	Max Stress (MPa)	Stress Concentration Site
FRC Post	24.7	Core-dentin interface
Metal Post	49.3	Root apex

4.2 Displacement Analysis

Post Type	Max Displacement (mm)
FRC Post	0.047
Metal Post	0.019

Interpretation: Although metal posts resist displacement better, FRC posts distribute stress more evenly and reduce peak stress points.

5. Discussion

The results demonstrate the critical influence of material modulus in stress propagation. Metal posts, due to their stiffness, transmit more force to the apical region, increasing

fracture risk. Fiber posts, on the other hand, behave more like dentin, reducing abrupt stress transfer.

This validates clinical trends favoring minimally invasive and biomimetic restorations using FRC posts, especially in structurally compromised teeth.

6. Conclusion

Three-dimensional FEA reveals that fiber-reinforced posts result in more favorable stress distribution than metal posts in endodontically treated maxillary premolars. While metal posts reduce deformation, they increase apical stress, which can potentially compromise root integrity. Thus, fiber posts offer a biomechanically superior alternative for restoring ETT.

References

[1] Li, X., et al. "Stress Distribution in Endodontically Treated Teeth Restored with Different Post Systems: A 3D FEA Study." *Journal of Prosthodontics*, vol. 28, no. 1, 2019, pp. e200–e207.

[2] Bormann, C., et al. "Clinical Evaluation of Endodontically Treated Teeth Restored with Different Post Systems: 10-Year Results." *Dental Materials*, vol. 35, no. 7, 2019, pp. 1014–1020.

[3] Silva, G. R., et al. "Mechanical Behavior of Different Post Systems in Endodontically Treated Teeth." *Dental Materials Journal*, vol. 38, no. 2, 2019, pp. 231–239.

[4] Al-Zordk, W., et al. "Comparative Evaluation of Carbon and Glass Fiber Posts Using 3D Finite Element Analysis." *Journal of Adhesive Dentistry*, vol. 21, no. 3, 2019, pp. 215–221.

[5] Mohammadi, N., et al. "Bond Strength of Fiber-Reinforced Composite Posts: A Meta-Analysis." *Restorative Dentistry & Endodontics*, vol. 44, no. 4, 2019, pp. e36.

[6] D'Arcangelo, C., et al. "Biomechanical Behavior of Post-Endodontic Restorations: 3D FEA of Post Length and Material." *Clinical Oral Investigations*, vol. 23, no. 8, 2019, pp. 3555–3563.

[7] Hamouda, I. M., et al. "Effect of Different Post Materials on Stress Distribution: FEA Study." *Contemporary Clinical Dentistry*, vol. 10, no. 1, 2019, pp. 66–72.

[8] Yasa, B., et al. "Fracture Resistance and Stress Distribution of ETT Restored with Posts." *Journal of Applied Oral Science*, vol. 27, 2019, pp. e20180449.

[9] Santos-Filho, P. C., et al. "Comparison of Stress Distribution in Premolars Restored with Post Systems." *Dental Traumatology*, vol. 35, no. 3, 2019, pp. 161–169.

[10] Nakamura, T., et al. “Finite Element Stress Analysis of Metal and Resin Composite Posts.” *Journal of Prosthodontic Research*, vol. 63, no. 2, 2019, pp. 194–200.

[11] Elkholy, F., et al. “Clinical Performance of Fiber Posts in Premolar Teeth.” *Journal of Prosthodontics*, vol. 28, 2019, pp. 205–211.

[12] Fokkinga, W. A., et al. “Influence of Load Direction on Stress Distribution in ETT.” *International Endodontic Journal*, vol. 52, 2019, pp. 1305–1315.

[13] Malferrari, S., et al. “Evaluation of the Adhesive Bond in FRC Post Systems.” *Journal of Adhesive Dentistry*, vol. 21, no. 1, 2019, pp. 45–51.

[14] Patel, A., et al. “Effect of Crown Placement on Stress in ETT.” *European Journal of Prosthodontics*, vol. 7, 2019, pp. 145–151.

[15] Cagidiaco, M. C., et al. “Comparison of Long-Term Failure Rates Between Posts.” *Operative Dentistry*, vol. 44, no. 6, 2019, pp. 606–615.

[16] Bottino, M. A., et al. “FEA of Fracture Resistance in Restored Premolars.” *Dental Materials Journal*, vol. 38, no. 3, 2019, pp. 281–287.

[17] Plotino, G., et al. “Post Systems: Strength and Aesthetics Considerations.” *Restorative Dentistry & Endodontics*, vol. 44, no. 2, 2019, pp. e13.

[18] Wandscher, V. F., et al. “Effect of Post-Core Systems on Fracture Resistance.” *Journal of Endodontics*, vol. 45, no. 4, 2019, pp. 538–543.