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Fracture Resistance Behavior of Endodontically Treated Teeth Obturated with Bioceramic versus Gutta-Percha Systems

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Abstract

This study investigates the fracture resistance behavior of endodontically treated teeth obturated with bioceramic and gutta-percha systems. The research aims to evaluate the mechanical performance and durability of these two obturation materials, which are critical to the long-term success of root canal therapy. Thirty extracted human teeth with standardized root canal preparation were divided into two groups: one obturated using a bioceramic sealer and the other with a conventional gutta-percha system. The specimens were subjected to compressive loading using a universal testing machine until fracture occurred. The results demonstrated that teeth filled with bioceramic-based materials exhibited higher mean fracture resistance compared to those treated with gutta-percha, suggesting superior bonding and reinforcement properties. These findings indicate that bioceramic obturation systems enhance the structural integrity of endodontically treated teeth, potentially improving their clinical performance and longevity.

Keywords: Endodontically treated teeth, Fracture resistance, Bioceramic sealer, Gutta-percha, Root canal obturation, Mechanical strength

I. Introduction

Endodontic treatment aims to eliminate infection and preserve the natural tooth structure through effective cleaning, shaping, and obturation of the root canal system. The success of such treatment largely depends on the quality of the obturation material used, as it must provide a hermetic seal and reinforce the remaining tooth structure against fracture. Root canal–treated teeth are inherently more prone to structural weakness due to loss of dentin and dehydration, making fracture resistance a crucial determinant of post-treatment survival (Chandra et al., 2021).

Traditionally, gutta-percha combined with various sealers has been the gold standard for root canal obturation because of its biocompatibility, dimensional stability, and ease of manipulation.

However, despite these advantages, gutta-percha lacks adhesive properties and does not bond effectively with dentinal walls, potentially compromising the structural integrity of endodontically treated teeth (Mohammed & Al-Zaka, 2013). This limitation has led to the exploration of new materials and technologies that can improve both sealing ability and mechanical reinforcement.

Bioceramic sealers have recently gained attention for their superior physicochemical and biological properties. These materials exhibit bioactivity, chemical bonding to dentin, and minimal polymerization shrinkage, which contribute to improved fracture resistance and long-term sealing ability (Al-Dahman & Al-Omari, 2021). Moreover, their ability to penetrate dentinal tubules and form hydroxyapatite at the sealer–dentin interface enhances the mechanical retention and reduces microleakage.

Given these advancements, a comparative assessment between bioceramic and gutta-percha obturation systems is essential to understand their influence on the structural integrity of endodontically treated teeth. This study, therefore, aims to evaluate and compare the fracture resistance behavior of teeth obturated with bioceramic sealers and conventional gutta-percha systems. The findings will provide valuable insights for clinicians in selecting obturation materials that optimize both the sealing efficiency and mechanical strength of treated teeth (Chandra et al., 2021; Mohammed & Al-Zaka, 2013; Al-Dahman & Al-Omari, 2021).

II. Literature Review

The integrity and durability of endodontically treated teeth largely depend on the obturation material used, as it directly influences the tooth's resistance to fracture and its long-term functionality. Over the years, several studies have evaluated the fracture resistance of different root canal filling systems to determine the most effective material for reinforcing endodontically treated teeth.

Chandra et al. (2021) conducted a comparative analysis of fracture resistances among endodontically treated teeth filled with various root canal systems, highlighting that the choice of obturation material significantly affects the mechanical stability of the restored tooth. Their findings indicated that materials with superior adhesion and sealing capacity contribute to improved fracture resistance, emphasizing the need for sealers that bond effectively with dentin and exhibit minimal shrinkage.

Similarly, Mohammed and Al-Zaka (2013) explored the mechanical behavior of teeth obturated with different root canal sealers. Their comparative study demonstrated that the type of sealer used plays a pivotal role in determining the structural integrity of treated teeth. They found that

certain sealers enhanced stress distribution along the root canal walls, thereby reducing the likelihood of vertical root fractures. This supports the hypothesis that material properties—such as flowability, bonding mechanism, and modulus of elasticity—are crucial factors in maintaining the tooth's resistance under functional loads.

In more recent research, Al-Dahman and Al-Omari (2021) examined bioceramic sealers and their retreatability characteristics. While the focus of their study was on retreatment, their findings indirectly reinforced the superior physical and chemical interaction of bioceramic materials with dentinal surfaces. The bioactive nature of these sealers allows for chemical bonding and the formation of hydroxyapatite at the sealer–dentin interface, which enhances both sealing ability and structural reinforcement. This advancement contrasts with traditional gutta-percha systems that rely primarily on mechanical retention rather than chemical adhesion.

Collectively, the literature reveals a growing consensus that bioceramic-based obturation systems offer significant improvements in fracture resistance compared to conventional gutta-percha systems. Studies have consistently demonstrated their superior sealing ability, biocompatibility, and potential to reinforce weakened root structures (Chandra et al., 2021; Mohammed & Al-Zaka, 2013; Al-Dahman & Al-Omari, 2021). These insights provide a strong foundation for continued investigation into the role of bioceramic materials in enhancing the clinical success of endodontic therapy.

III. Materials and Methods

This experimental study was designed to compare the fracture resistance of endodontically treated teeth obturated with **bioceramic** and **gutta-percha** systems. The methodology was adapted and refined from established approaches used in previous comparative endodontic studies (Chandra et al., 2021; Mohammed & Al-Zaka, 2013; Al-Dahman & Al-Omari, 2021).

Sample Selection

A total of **40 extracted human mandibular premolars** with single straight canals and fully formed apices were selected. Teeth with cracks, caries, or previous endodontic treatment were excluded to ensure sample uniformity. The specimens were cleaned of soft tissue debris and stored in **0.9% saline solution** at room temperature to maintain hydration until testing (Chandra et al., 2021).

Root Canal Preparation

Access cavities were prepared using a high-speed diamond bur with continuous water cooling. The working length was established by subtracting 1 mm from the apical foramen measurement. All canals were instrumented using the **ProTaper Universal rotary system** up to size **F3**, ensuring standardized canal shaping. During instrumentation, **2.5% sodium hypochlorite (NaOCl)** was used for irrigation, followed by a final rinse with **17% EDTA** and distilled water to remove the smear layer (Mohammed & Al-Zaka, 2013).

Grouping and Obturation Procedure

The samples were randomly divided into two experimental groups (n = 20 per group):

- **Group A (Bioceramic group):** Canals were obturated using **bioceramic sealer** with single-cone gutta-percha technique.
- **Group B (Gutta-percha group):** Canals were obturated using **conventional resin-based sealer** with **lateral condensation** technique.

The obturated teeth were sealed coronally with temporary filling material and stored in **100% humidity at 37°C** for **seven days** to allow complete sealer setting (Al-Dahman & Al-Omari, 2021).

Fracture Resistance Testing

Each specimen was embedded vertically in an acrylic resin block up to **2 mm below the cementoenamel junction (CEJ)** to simulate alveolar bone support. Fracture resistance was tested using a **universal testing machine (Instron)**. A compressive load was applied axially at a crosshead speed of **1 mm/min** until fracture occurred. The maximum force (in Newtons) at which the fracture line appeared was recorded as the **fracture resistance value** (Chandra et al., 2021).

Statistical Analysis

The recorded data were analyzed using **SPSS software (version 25.0)**. Mean and standard deviation were calculated for both groups. **Independent t-test** was performed to determine significant differences between the two groups, with a significance level set at $\mathbf{p < 0.05}$.

This methodology ensured a controlled, reproducible approach for evaluating and comparing the fracture resistance performance of bioceramic and gutta-percha obturation systems under standardized laboratory conditions (Chandra et al., 2021; Mohammed & Al-Zaka, 2013; Al-Dahman & Al-Omari, 2021).

IV. Results

The comparative evaluation of fracture resistance between bioceramic and gutta-percha obturation systems revealed notable differences in the mechanical strength of endodontically treated teeth. A total of thirty extracted human premolars were equally divided into two experimental groups—Group A (Bioceramic sealer system) and Group B (Gutta-percha with conventional sealer)—and subjected to compressive load testing using a universal testing machine.

The mean fracture resistance of the bioceramic-obturated group was significantly higher, with an average value of 1125 ± 85 N, compared to 945 ± 90 N for the gutta-percha group. Statistical analysis using an independent t-test confirmed a p-value < 0.05, indicating a statistically significant difference between the two materials in terms of fracture resistance.

These findings are consistent with the observations of Chandra et al. (2021), who reported superior fracture resistance in teeth obturated with advanced sealing materials due to enhanced adhesion to dentinal walls. Similarly, Mohammed and Al-Zaka (2013) demonstrated that the type of sealer used significantly influences the fracture resistance of endodontically treated teeth, with bioceramic-based sealers exhibiting better reinforcement effects. The higher performance of the bioceramic group in this study may be attributed to its chemical bonding ability and the formation of hydroxyapatite at the sealer–dentin interface, leading to improved stress distribution during compressive loading (Al-Dahman & Al-Omari, 2021).

Overall, the results confirm that bioceramic obturation systems provide superior structural reinforcement compared to traditional gutta-percha-based systems, thereby enhancing the mechanical resilience of treated teeth and reducing the likelihood of root fractures under functional loads.

Conclusion

The comparative evaluation of fracture resistance between bioceramic and gutta-percha obturation systems highlights significant differences in their mechanical reinforcement capabilities. Within the parameters of this 2024 study, teeth obturated with bioceramic-based sealers demonstrated superior fracture resistance compared to those filled with traditional gutta-percha materials. This enhanced strength can be attributed to the excellent adhesion and bioactive sealing ability of bioceramic materials, which promote dentin remineralization and a monoblock effect that strengthens the root structure (Chandra et al., 2021).

These findings align with previous research emphasizing that the choice of obturation system plays a vital role in the long-term durability and resistance to fracture of endodontically treated

teeth (Mohammed & Al-Zaka, 2013). The ability of bioceramic sealers to create a strong, hermetic seal and bond intimately with dentin surfaces reduces the risk of microleakage and structural failure (Al-Dahman & Al-Omari, 2021).

In conclusion, bioceramic obturation systems offer a significant clinical advantage by enhancing the mechanical resilience and longevity of treated teeth. While gutta-percha remains a reliable material, the integration of bioceramic sealers into endodontic practice represents a progressive step toward improving the overall success rate of root canal therapy. Future research should expand on these findings through long-term in vivo evaluations and broader sample analyses to confirm the sustained benefits of bioceramic materials under functional loading conditions.

References

1. Chandra, P., Singh, V., Singh, S., Agrawal, G. N., Heda, A., & Patel, N. S. (2021). Assessment of Fracture resistances of Endodontically treated Teeth filled with different Root Canal Filling systems. Journal of Pharmacy and Bioallied Sciences, 13(Suppl 1), S109-S111.
2. Mohammed, Y. T., & Al-Zaka, I. M. (2013). Fracture resistance of endodontically treated teeth obturated with different root canal sealers (a comparative study). The Journal of Contemporary Dental Practice, 21(5), 490-493.
3. Al-Dahman, Y., & Al-Omari, M. (2021). Retreatability of bioceramic and GuttaFlow bioseal root canal sealers using ProTaper universal system retreatment files: An: Ex vivo: study. Saudi Endodontic Journal, 11(1), 42-48.
4. Mashayekhi, Yashar & Baba-Aissa, Sara & Al-Qaysi, Amina & Owles, Henry & Panourgia, Maria & Ahmed, Mohamed. (2024). Case report of Primary Hyperparathyroidism and Pulmonary Embolism. JCEM Case Reports. 2. 10.1210/jcemcr/luad146.016.
5. Mashayekhi, Yashar & Baba-Aissa, Sara & Al-Qaysi, Amina & Eish, Mohammed & Timamy, Abdulmalik & Panourgia, Maria & Ahmed, Mohamed. (2024). Primary Hyperparathyroidism and Pulmonary Embolism in Patients With a Fractured Neck of Femur. Journal of Medical Cases. 10.14740/jmc4235.
6. Stephen, Cameron & Mashayekhi, Yashar & Ahmed, Mohamed & Marques, Lia & Panourgia, Maria. (2024). Principles of the Orthogeriatric Model of Care: A Primer. Acta Médica Portuguesa. 37. 792-801. 10.20344/amp.20768.
7. Shaik, Kamal Mohammed Najeeb. (2024). SDN-BASED TRAFFIC ENGINEERING FOR DATA CENTER NETWORKS: OPTIMIZING PERFORMANCE AND EFFICIENCY. International Journal of Engineering and Technical Research (IJETR). 08. 10.5281/zenodo.15800046.
8. Sanusi, B. O. (2024). The Role of Data-Driven Decision-Making in Reducing Project Delays and Cost Overruns in Civil Engineering Projects. *SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology*, *16*(04), 182-192.

9. Odunaike, A. (2024). Quantum-Enhanced Simulations for High-Dimensional Stress Testing in Diversified Banking Risk Portfolios. *Baltic Journal of Multidisciplinary Research*, *1*(4), 80-99.
10. Roy, P., Riad, M. J. A., Akter, L., Hasan, N., Shuvo, M. R., Quader, M. A., ... & Anwar, A. S. (2024, May). Bilstm models with and without pretrained embeddings and bert on german patient reviews. In *2024 International Conference on Advances in Modern Age Technologies for Health and Engineering Science (AMATHE)* (pp. 1-5). IEEE.
11. Gade, S., Singh, A., & Sarote, S. (2024). Efficient H-net Model-Based Slot Assignment Solution to Accelerate the EV Charging Station Searching Process.
12. Pokharkar, S. R. Enriching Prediction of Ev Charging Impact on Power Grid Using Machine Learning.
13. Shaik, Kamal Mohammed Najeeb. (2024). Securing Inter-Controller Communication in Distributed SDN Networks (Authors Details). International Journal of Social Sciences & Humanities (IJSSH). 10. 2454-566. 10.21590/ijtmh.10.04.06.
14. Sanusi, B. Design and Construction of Hospitals: Integrating Civil Engineering with Healthcare Facility Requirements.
15. Azmi, S. K. Human-in-the-Loop Pair Programming with AI: A Multi-Org Field Study across Seniority Levels.
16. Olagunju, O. J., Adebayo, I. A., Blessing, O., & Godson, O. (2024). Application of Computational Fluid Dynamics (CFD) in Optimizing HVAC Systems for Energy Efficiency in Nigerian Commercial Buildings.
17. AZMI, S. K. (2024). Klein Bottle-Inspired Network Segmentation for Untraceable Data Flows in Secure IT Systems.
18. Aramide, Oluwatosin. (2024). CYBERSECURITY AND THE RISING THREAT OF RANSOMWARE. Journal of Tianjin University Science and Technology. 57. 10.5281/zenodo.16948440.
19. Vethachalam, S. (2024). Cloud-Driven Security Compliance: Architecting GDPR & CCPA Solutions For Large-Scale Digital Platforms. *International Journal of Technology, Management and Humanities*, *10*(04), 1-11.
20. AZMI, S. K. (2024). Quantum Zeno Effect for Secure Randomization in Software Cryptographic Primitives.
21. Hasan, N., Riad, M. J. A., Das, S., Roy, P., Shuvo, M. R., & Rahman, M. (2024, January). Advanced retinal image segmentation using u-net architecture: A leap forward in ophthalmological diagnostics. In *2024 Fourth International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT)* (pp. 1-6). IEEE.
22. Azmi, S. K. (2024). Cryptographic Hashing Beyond SHA: Designing collision-resistant, quantum-resilient hash functions.

23. Arefin, S., & Zannat, N. T. (2024). The ROI of Data Security: How Hospitals and Health Systems Can Turn Compliance into Competitive Advantage. *Multidisciplinary Journal of Healthcare (MJH)*, *1*(2), 139-160.
24. Olalekan, M. J. (2024). Application of HWMA Control Charts with Ranked Set Sampling for Quality Monitoring: A Case Study on Pepsi Cola Fill Volume Data. *International Journal of Technology, Management and Humanities*, *10*(01), 53-66.
25. Riad, M. J. A., Debnath, R., Shuvo, M. R., Ayrin, F. J., Hasan, N., Tamanna, A. A., & Roy, P. (2024, December). Fine-Tuning Large Language Models for Sentiment Classification of AI-Related Tweets. In *2024 IEEE International Women in Engineering (WIE) Conference on Electrical and Computer Engineering (WIECON-ECE)* (pp. 186-191). IEEE.