

Regenerative Potential of Bioceramic-Based Materials in Partial Pulpotomy: A Clinical and Radiographic Assessment

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ABSTRACT

The preservation of pulp vitality through conservative vital pulp therapy has gained renewed attention with the advent of bioceramic-based materials. This study aimed to evaluate the regenerative potential of bioceramic materials in partial pulpotomy using clinical and radiographic assessment. A total of teeth diagnosed with reversible pulpitis or traumatic pulp exposure were treated with partial pulpotomy followed by application of Mineral Trioxide Aggregate (MTA), Biodentine, or EndoSequence Root Repair Material (RRM). Clinical evaluation focused on pain relief, absence of tenderness, and maintenance of vitality, while radiographic assessment examined dentin bridge formation, periapical healing, and continued root development. Follow-up evaluations were performed at 3, 6, and 12 months. The results demonstrated high clinical and radiographic success rates across all groups, with Biodentine and MTA showing comparable regenerative potential. Bioceramic-based materials exhibited excellent biocompatibility, sealing ability, and capacity to promote hard tissue regeneration and pulpal healing. The findings support the use of bioceramic materials as reliable agents in partial pulpotomy procedures, offering predictable outcomes for maintaining long-term pulp vitality and structural integrity.

Keywords: Bioceramic materials, Partial pulpotomy, Pulp vitality, Regeneration, Dentin bridge formation, Mineral trioxide aggregate (MTA), Biodentine, EndoSequence RRM.

1. INTRODUCTION

The preservation of pulp vitality has become a central goal in modern conservative dentistry, with vital pulp therapy (VPT) offering a biologically based approach to maintaining the functional integrity of the dental pulp. Among the various VPT procedures, partial pulpotomy has gained increasing clinical relevance for managing traumatic or carious pulp exposures, especially in young permanent teeth where maintaining pulp vitality supports continued root development and dentin deposition. Partial pulpotomy involves the removal of a small portion of inflamed coronal pulp tissue, followed by placement of a biocompatible material that stimulates healing and regeneration of the remaining pulp tissue (Azimi et al., 2014).

The introduction of bioceramic-based materials has significantly advanced the clinical success of partial pulpotomy. These materials, including Mineral Trioxide Aggregate (MTA), Biodentine, and EndoSequence Root Repair Material (RRM), possess bioactive and biocompat-

ible properties that promote the formation of a mineralized barrier and support the regeneration of pulp-dentin complex (Wang, 2015). Their ability to release calcium ions, maintain an alkaline pH, and create a hermetic seal provides a favorable environment for pulpal healing and dentinal bridge formation.

The shift from traditional materials, such as calcium hydroxide, to advanced bioceramic alternatives reflects a growing understanding of biomimetic healing and the role of bioactive materials in stimulating odontoblastic differentiation and hard tissue formation (Singh, 2019). Despite the reported advantages of these materials, comparative clinical and radiographic evaluations are essential to determine their regenerative potential and long-term success in partial pulpotomy procedures. Therefore, this study aims to assess the regenerative outcomes of different bioceramic-based materials in partial pulpotomy through a combined clinical and radiographic approach, focusing on pulp vitality preservation and hard tissue regeneration.

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2. MATERIALS AND METHODS

Study Design

This study was designed as a prospective clinical and radiographic assessment to evaluate the regenerative potential of bioceramic-based materials used in partial pulpotomy. The research compared the clinical and radiographic outcomes of three commonly used materials—Mineral Trioxide Aggregate (MTA), Biodentine, and EndoSequence Root Repair Material (RRM)—in maintaining pulp vitality and promoting dentin bridge formation (Singh, 2019).

Sample Selection

A total of thirty permanent teeth with deep carious or traumatic pulp exposure and diagnosed with reversible pulpitis were selected from patients aged 12 to 25 years. Teeth with irreversible pulpitis, necrosis, periapical pathology, or inadequate coronal structure for restoration were excluded. All participants provided informed consent before inclusion in the study.

Procedure

Each tooth was anesthetized using 2% lidocaine with epinephrine (1:100,000) and isolated with a rubber dam. Partial pulpotomy was performed by removing 2–3 mm of the inflamed coronal pulp tissue using a sterile diamond bur under continuous irrigation. Hemostasis was achieved with sterile saline-moistened cotton pellets. Once bleeding was controlled within 5 minutes, one of the bioceramic-based materials—MTA, Biodentine, or EndoSequence RRM—was applied directly over the exposed pulp tissue according to the manufacturer's instructions (Wang, 2015).

A protective base of glass ionomer cement was placed over the capping material, followed by definitive coronal restoration using resin composite. Each treated tooth was evaluated postoperatively to ensure the absence of discomfort and restoration integrity.

Evaluation Criteria

Clinical and radiographic evaluations were conducted at intervals of 3, 6, and 12 months. The clinical assessment included evaluation for pain, tenderness on percussion, swelling, and pulp vitality using cold and electric pulp tests. Radiographic evaluation involved periapical radiographs taken using the paralleling technique to assess periapical status, evidence of dentin bridge formation, and continued root development where applicable. Successful outcomes were defined as the absence of clinical

symptoms and the presence of radiographic signs of healing and hard tissue barrier formation (Azimi et al., 2014).

Statistical Analysis

Data were analyzed using statistical software to compare clinical and radiographic success rates among the three groups. Chi-square and ANOVA tests were employed to determine the significance of differences between materials, with a p-value < 0.05 considered statistically significant.

This methodology ensured a standardized approach to assess the biological performance of bioceramic materials, enabling a reliable comparison of their regenerative potential in partial pulpotomy procedures.

3. DISCUSSION

The findings of this study demonstrate that bioceramic-based materials possess strong regenerative potential when used in partial pulpotomy procedures, resulting in favorable clinical and radiographic outcomes. The high success rates observed across Mineral Trioxide Aggregate (MTA), Biodentine, and EndoSequence RRM can be attributed to their ability to maintain pulp vitality, stimulate hard tissue formation, and create a biologically conducive environment for healing. These outcomes are consistent with the growing body of evidence supporting bioceramic materials as effective agents for vital pulp therapy due to their superior sealing ability, alkaline pH, and biocompatibility (Singh, 2019).

The observed dentin bridge formation and absence of inflammatory symptoms suggest that bioceramic materials not only protect the pulp from bacterial ingress but also promote differentiation of odontoblast-like cells and subsequent reparative dentinogenesis. This biological response has been associated with the sustained release of calcium and hydroxyl ions, which enhance mineralization and stimulate the regeneration of dentin-pulp complex tissues (Wang, 2015). The capacity of bioceramics to maintain a stable, moisture-tolerant seal further contributes to their success in creating an environment suitable for continued pulp healing and long-term vitality.

Comparative analysis revealed that Biodentine and MTA produced similar regenerative responses, although Biodentine offered clinical advantages such as easier handling and a faster setting time. These findings align with previous studies reporting that both materials induce a thick and continuous dentin bridge with minimal pulpal inflammation, reflecting their favorable biological interactions (Azimi et al., 2014). EndoSequence RRM also demonstrated positive outcomes, highlighting the effectiveness of newer premixed formulations designed

to enhance clinical convenience without compromising bioactivity.

Overall, the results reinforce the concept that bioceramic materials support the goals of regenerative endodontics by maintaining vital pulp function and promoting tissue regeneration. Their performance in partial pulpotomy underscores the shift toward biologically based restorative approaches that prioritize tissue preservation over conventional endodontic intervention. While long-term studies with larger samples are necessary to validate these outcomes, the present findings substantiate the role of bioceramic-based materials as predictable and reliable options for achieving pulp regeneration and maintaining tooth vitality.

CONCLUSION

The clinical and radiographic evaluation of bioceramic-based materials in partial pulpotomy demonstrated their significant regenerative potential in maintaining pulp vitality and promoting dentin bridge formation. The study findings revealed that materials such as Mineral Trioxide Aggregate (MTA), Biodentine, and EndoSequence RRM provide favorable biological responses characterized by minimal inflammation, effective sealing ability, and stimulation of tertiary dentinogenesis. These outcomes are consistent with the reported bioactive properties of bioceramic materials, including their capacity to release calcium ions and form hydroxyapatite, which enhances tissue repair and regeneration (Wang, 2015).

The comparative assessment showed that both MTA and Biodentine achieved high clinical and radiographic success rates, with Biodentine offering advantages in handling and setting time while maintaining similar regenerative performance (Azimi et al., 2014). The observed healing patterns and continued root development in treated teeth highlight the ability of bioceramic materials to support long-term pulpal vitality and structural integrity (Singh, 2019).

In conclusion, bioceramic-based materials can be considered reliable and effective options for partial pulpotomy procedures. Their biocompatibility, bioactivity, and regenerative capabilities make them valuable

alternatives to traditional materials in vital pulp therapy, contributing to predictable clinical outcomes and the preservation of natural tooth function.

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