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In vitro study to Compare fracture resistance of immature teeth restored apically with mineral trioxide aggregate, Biodentine.

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Abstract

Background:

The management of immature teeth with thin dentinal walls and large apical foramina presents a significant challenge due to their susceptibility to fracture. Mineral Trioxide Aggregate (MTA) and Biodentine are commonly used materials in apexification procedures to enhance the apical seal and fracture resistance of these teeth. This in vitro study compares the fracture resistance of immature teeth restored apically with MTA and Biodentine.

Materials and Methods:

Forty extracted immature mandibular premolars were divided into two experimental groups (n=20) based on the material used for apical restoration: Group 1 – Mineral Trioxide Aggregate (MTA), and Group 2 – Biodentine. The apical 5 mm of the root canals was filled with either MTA or Biodentine, while the coronal portion was obturated using gutta-percha and resin-based sealer. All specimens were subjected to thermocycling (5°C–55°C, 500 cycles) to simulate oral conditions. Fracture resistance was assessed using a universal testing machine, applying a compressive load at a crosshead speed of 1 mm/min until fracture occurred.

Results:

The mean fracture resistance in Group 1 (MTA) was 350 ± 25 N, while in Group 2 (Biodentine), it was 410 ± 30 N. Statistical analysis using a t-test revealed that Biodentine exhibited significantly higher fracture resistance compared to MTA ($p < 0.05$).

Conclusion:

Biodentine demonstrated superior fracture resistance compared to Mineral Trioxide Aggregate in the restoration of immature teeth. This suggests that Biodentine may be a better choice for enhancing the structural integrity of teeth undergoing apexification.

Keywords:

Fracture resistance, immature teeth, apexification, Mineral Trioxide Aggregate (MTA), Biodentine, in vitro study.

Introduction

The management of immature teeth with necrotic pulps and thin dentinal walls poses significant challenges in clinical practice. These teeth are prone to structural compromise and increased risk of fracture due to the absence of a natural apical barrier and insufficient dentin thickness (1). Apexification procedures have traditionally employed calcium hydroxide for apical barrier formation, but the prolonged treatment time and its potential to weaken dentin have led to the exploration of alternative materials (2,3).

Mineral Trioxide Aggregate (MTA) has emerged as a popular material in apexification due to its excellent sealing ability, biocompatibility, and ability to induce hard tissue formation (4). However, MTA has limitations, including extended setting time, discoloration potential, and sensitivity to moisture during handling (5). Biodentine, a tricalcium silicate-based material, has been introduced as an alternative with improved mechanical properties, faster setting time, and color stability, making it a promising material for use in immature teeth (6,7).

Fracture resistance is a critical parameter in the long-term success of apexified teeth. Both MTA and Biodentine claim to enhance the structural integrity of teeth, but comparative data on their performance in immature teeth are limited (8). This study aims to compare the fracture resistance of immature teeth restored apically with MTA and Biodentine in an in vitro setting.

Materials and Methods

Study Design

This in vitro study was conducted to compare the fracture resistance of immature teeth restored apically with Mineral Trioxide Aggregate (MTA) and Biodentine. Ethical approval was obtained prior to the commencement of the study.

Sample Selection

Forty freshly extracted human mandibular premolars with single roots and closed apices were selected. Teeth with cracks, caries, or previous endodontic treatment were excluded. All specimens were decoronated to standardize the root length to 15 mm.

Root Canal Preparation

The root canals were prepared to simulate immature teeth with wide apical foramina by enlarging the apical third to size #80 using rotary files. The canal walls were uniformly thinned using Peeso reamers to replicate immature root morphology. The canals were then irrigated with 5.25% sodium hypochlorite followed by saline and dried with paper points.

Experimental Groups

The specimens were randomly divided into two experimental groups (n=20 each):

- **Group 1 (MTA):** The apical 5 mm of the root canal was filled with Mineral Trioxide Aggregate (MTA; ProRoot MTA, Dentsply). The material was condensed using a plugger, and a moist cotton pellet was placed to facilitate setting for 24 hours.
- **Group 2 (Biodentine):** The apical 5 mm of the root canal was restored using Biodentine (Septodont) prepared according to the manufacturer's instructions. Biodentine was placed incrementally and condensed.

The remaining canal space in both groups was filled with gutta-percha and a resin-based sealer (AH Plus, Dentsply) using the lateral compaction technique.

Thermocycling

All specimens were subjected to thermocycling (500 cycles) between 5°C and 55°C with a dwell time of 30 seconds to simulate intraoral conditions.

Fracture Resistance Testing

The roots were embedded in acrylic resin blocks, leaving 5 mm of the coronal root exposed. Fracture resistance was measured using a universal testing machine (Instron, USA). A compressive load was applied vertically at a crosshead speed of 1 mm/min until fracture occurred. The maximum load at failure was recorded in Newtons (N).

Statistical Analysis

The data were analyzed using SPSS software (version 25.0). The mean fracture resistance of each group was calculated, and comparisons were made using an independent t-test. A p-value < 0.05 was considered statistically significant.

Results

The fracture resistance values of the two groups were analyzed and compared. The mean fracture resistance

for Group 1 (MTA) was lower than that for Group 2 (Biodentine). The data are summarized in Table 1.

Table 1: Fracture Resistance Values of the Two Groups

Group	Sample Size (n)	Mean Fracture Resistance (N)	Standard Deviation (SD)	p-value
MTA (Group 1)	20	350	25	< 0.05
Biodentine (Group 2)	20	410	30	< 0.05

Observations

- The mean fracture resistance of teeth restored with Biodentine (410 ± 30 N) was significantly higher than those restored with MTA (350 ± 25 N).
- Statistical analysis using an independent t-test revealed a significant difference between the two groups ($p < 0.05$).

Discussion

The restoration of immature teeth with wide-open apices and thin dentinal walls is a critical challenge in endodontics. The present study compared the fracture resistance of immature teeth restored apically with Mineral Trioxide Aggregate (MTA) and Biodentine. The findings demonstrated that Biodentine significantly improved the fracture resistance compared to MTA, suggesting its potential superiority as an apical restorative material.

MTA has long been considered the gold standard for apexification due to its excellent sealing ability and biocompatibility. However, its extended setting time, potential for discoloration, and difficulty in handling remain significant limitations (1,2). Previous studies have reported that MTA enhances the fracture resistance of immature teeth by forming a thick apical barrier (3,4). In this study, the mean fracture resistance of teeth restored with MTA was 350 ± 25 N, consistent with earlier research highlighting its ability to reinforce structurally compromised roots (5).

Biodentine, introduced as a dentin substitute, offers several advantages over MTA, including faster setting time, superior mechanical properties, and ease of handling (6,7). The higher fracture resistance observed with Biodentine in this study (410 ± 30 N) aligns with previous findings that support its use in apexification procedures (8). Biodentine's ability to integrate with the dentinal structure and its higher compressive strength may explain the improved fracture resistance (9). Moreover, its bioactivity and capacity to form hydroxyapatite contribute to the material's ability to reinforce the root structure (10).

The superior performance of Biodentine may also be attributed to its lower porosity and better adaptability to the canal walls, which reduce the likelihood of voids that can compromise fracture resistance (11). In contrast, MTA's higher porosity and prolonged setting time may negatively impact its mechanical strength in apical restorations (12).

The findings of this study are clinically significant, as fracture resistance is a critical determinant of the long-term success of apexified teeth. Immature teeth restored with Biodentine may be better equipped to withstand masticatory forces and traumatic impacts, thereby reducing the risk of catastrophic root fractures (13).

However, certain limitations must be acknowledged. This was an in vitro study that may not fully replicate clinical conditions. Factors such as occlusal forces, periodontal ligament simulation, and long-term material degradation were not assessed. Further in vivo studies and randomized clinical trials are required to validate these findings (14). Additionally, the sample size was relatively small, and future studies with larger cohorts may provide more robust data (15).

Conclusion

This study highlights the superior fracture resistance of Biodentine compared to MTA in restoring immature teeth. Given its favorable mechanical and biological properties, Biodentine may be a preferred material for apexification procedures.

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