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FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH WITH DIFFERENT ROOT END FILLING MATERIALS

Dentistry

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ABSTRACT

To assess and compare the fracture resistance of endodontically treated teeth when the retrograde preparations were restored either with MTA or Biodentine or Bio-C repair. Thirty human mandibular premolars were randomly assigned into three groups (n=10 per group). After completing conventional root canal treatment and performing apical root resection, 3 mm deep retrograde cavities were prepared using ultrasonic tips. The cavities were filled MTA, Biodentine, Bio-C repair. Fracture resistance was tested using an Instron machine. Data were analyzed using one-way ANOVA, followed by Tukey's multiple post-hoc tests. Among the root-end filled materials that were tested highest strength for fracture was exhibited by MTA when compared to Biodentine. Among the tested root filled materials Bio-C repair showed less fracture resistance whereas MTA exhibited highest fracture resistance (p=0.0001). Teeth that underwent endodontic treatment and were restored with MTA or Biodentine as root-end filling materials demonstrated greater fracture resistance than those restored with Bio-C repair. Bio-C repair, when used as a retrofilling material, did not improve the fracture strength of root canal-treated teeth.

KEYWORDS

Root end filling materials, fracture resistance, universal testing machine

INTRODUCTION

Root canal therapy aims to eradicate pathological microbiota and prevent future infection within the root canals. Despite the success rates of 97% have been reported for the initial root canal treatment (Friedman 2002), failure may occur after treatment, mainly owing to incomplete removal of the pathogenic microbiota(Wong J et al., 2021). However, when root canal re-treatment is not feasible, when it fails, when itis unlikely that it can improve on the previous result or when biopsy of the periapical lesion is necessary, a surgical intervention consisting of root-end resection with or without root-end filling might be indicated and represents the last chance for avoiding tooth extraction. The surgical removal of a periapical lesion, resection of the apical portion of the root, disinfection, and sealing of the apical portion of the remaining root canal comprise root-end resection, also known as endodontic surgery, peri radicular surgery, periapical/apical surgery, or apicoectomy (Gutmann 1991).[1]

Contemporary micro-surgical techniques and advanced root-end filling materials have helped to improve the outcome of endodontic surgery (reported a favorable healing outcome of 88–96%). The application of root repair materials is one of the key procedure while doing root end procedures by which the hermetic seal is provided to the periapical area for preventing the invasion of microorganisms and the byproducts to enter the peri-radicular space through the root canal system. When root-end fillings are not used in conjunction with peri-radicular curettage, the reason of leaking remains. Majority of studies that have looked at the clinical outcomes of surgical endodontic therapy have hypothesized that the choice of material for root-end fillings is a predictor of the clinical outcome of endodontic surgery.[2]

MTA:

Numerous in vitro and in vivo studies demonstrating improved antibacterial activity, sealing ability, bioactivity, and cytocompatibility. Despite several drawbacks such as extended setup times and handling issues, MTA has been extensively used in endodontics with consistent positive clinical outcomes. Recent clinical studies show not only short-term success but also long-term follow-ups of MTA using as the root-end filling material.[3]

Biodentin: Biodentin is now to be considered as an alternative to MTA because of its similar properties with that of MTA and has faster setting time. The primary constituents of MTA found in biodentin powder are calcium carbonate, dicalcium silicate, and tricalcium silicate.

Bio- C Repair: For readily use, Bio-C Repair was created with the goal of streamlining the operating procedure. It is biocompatible, promotes biomineralization, and has demonstrated cytocompatibility outcomes comparable to MTA. While calcium ions can be released by calcium silicate-based bioceramic compositions, metal ions addition increases bioactivity and causes total regeneration and repair. Thus, Bio-C Repair ions, which is still in the experimental stage, is a cement that contains metallic particles.[4]

Although a variety of root-end filling materials are available but they did not fulfil the ideal requisites of a root end filling material. Because of decreased dentine organic matrix and thickness, which can result in root fractures, teeth with endodontic treatment have demonstrated 50% less strength than healthy teeth. Additionally, the changed crown to root ratio following an apicoectomy weakens the tooth periodontal support, which increases the risk of root fracture and unfavourable stress distribution.

MATERIALS AND METHODS

Thirty intact mandibular premolars with a single root canal and newly extracted with mature apex for orthodontic purposes were obtained from the Oral and Maxillofacial Surgery department and were included in the study. Remaining soft tissue was cleared of calculus and plaque, and it was kept within 0.1% thymol solution until the procedure was scheduled.

Working length is assessed visually, access cavities are made using an endo access bur, and preoperative periapical radiographs are obtained.

Up until size #40, apical preparation is carried out. After that, a step-back approach is applied, reducing each file by 1 mm until size #60. Two millilitres of 3% NaOCl, three millilitres of 17% EDTA, and five millilitres of saline are used for the last irrigation of the root canals. Absorbent paper points are used to eliminate excess moisture.

Cold lateral condensation is used to obturate teeth using 2% taper 40 gutta percha cones, and radiography is used to evaluate each obturated tooth. 3mm of the root end is excised with a 0^0bevel by using a # fissure 702 bur for all teeth treated with root canal therapy then 3mm retrograde preparations were done with ultrasonic tips. (Figure 1a,1b).

Figure 1: a) Root end resection b) retrograde preparation

Teeth randomly divided into three groups (n=10)
Group-A: MTA
Group-B: Biodentin
Group-C: Bio C Repair

MTA is mixed in accordance with manufacturer's guidelines. The material is inserted into the cavity, compressed with a plugger, and any excess is taken out and wiped with a moist piece of gauze.

Following biodentine manipulation, the material is packed and compressed into cavities using a plugger, teeth are cleaned using a cotton pellet that has been soaked, and wet gauze is used to cover them. The pre-mixed syringe is used to insert the Bio C Repair putty. Using plastic filling tools, material is inserted into the cavities. Excess material is then eliminated by compacting it using a plugger.

Following root end filling, a universal testing equipment is used to assess the teeth's fracture resistance. (Figure 2)

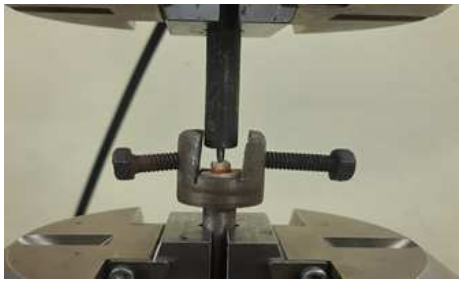

Figure 2: Fracture resistance testing using universal testing machine

RESULTS

Among the root-end filled materials that were tested (MTA, Biodentine, Bio-C repair) highest strength for fracture was exhibited by MTA when compared to Biodentine. Among the tested root filled materials Bio-C repair showed less fracture resistance whereas MTA exhibited highest fracture resistance (p=0.0001).

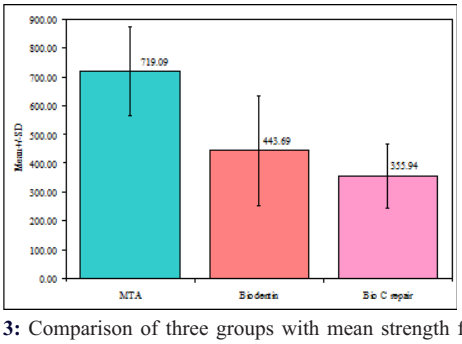

Figure 3: Comparison of three groups with mean strength fracture resistance

Table 1: Comparison of three groups with mean fracture resistance by one way ANOVA

Sources of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-value	p-value
Between groups	2	718087.92	359043.96	14.9701	0.0001 *
Within groups	27	647570.47	23984.09		
Total	29	1365658.39			

*p<0.05

DISCUSSION

Orthograde root canal therapy typically provides favorable outcomes for patients, thanks to advancements in materials and techniques. However, treatment failures still occur in 4% to 15% of cases. These failures are often attributed to the complexity of the root canal system and the challenge of eliminating bacteria, their by-products, and toxins. In such cases, conventional orthograde endodontic retreatment is the preferred initial approach.[5]

When non-surgical treatments fail to address persistent periradicular pathosis, periradicular surgery becomes a viable option, offering predictable results in many situations. Teeth that have received endodontic treatment are about 50% less durable than healthy teeth, primarily due to the loss of organic material and the thinning of dentin, making them more prone to root fractures.[6] Additionally, performing an apicoectomy can negatively impact the crown-to-root ratio, leading to reduced periodontal support and uneven stress distribution, which further heightens the likelihood of fractures.[7]

Selecting the right root-end filling material during periapical surgery is essential to achieving a successful treatment outcome. The material must promote the regeneration of periradicular tissue while also strengthening the root against fracture.[8] Mandibular premolar teeth, which are subject to the highest masticatory stresses and are prone to vertical root fractures, were the focus of this study to simulate clinical conditions.

Bioceramic materials, MTA, Biodentine, and Bio-C Repair were chosen as retrograde filling materials in this investigation due to their demonstrated potential to encourage osteoblastic activity and hard tissue formation in the peri-radicular region. The study rejected the null hypothesis, as the choice of retrograde filling material significantly influenced the fracture resistance of root-treated teeth. Among the investigated materials, MTA exhibited the highest fracture resistance, outperforming both Biodentine and Bio-C Repair.

Earlier research has evaluated the sealing properties of ProRoot MTA and Biodentine as root-end filling materials, highlighting significant differences in their performance. Biodentine demonstrated reduced microleakage compared to ProRoot MTA within 24 hours of setting. The formation of calcium- or phosphate-rich crystalline deposits during Biodentine setting process is believed to reduce the gap between the material and the tooth. In contrast, ProRoot MTA's longer setting time contributed to increased microleakage during the initial 24 hours. Clinically, this makes the setting time a critical factor, as Biodentine faster setting reduces the risk of dislodgement and contamination during hardening. Furthermore, Biodentine superior handling properties—characterized by ease of manipulation and condensation—make it more convenient for clinicians compared to ProRoot MTA's grainy texture and inconsistent handling.

Additionally, MTA has been shown to release bioactive molecules that interact with the dentin matrix, potentially preserving its organic composition. Research suggests that the interaction between MTA and dentin may help reinforce dentin integrity. However, bioceramic materials, including Bio-C Repair, have emerged as alternatives to MTA, addressing some of its limitations. Bio-C Repair's ready-made paste form offers ease of use, enhancing efficiency during clinical procedures. Studies comparing Bio-C Repair to Biodentine and ProRoot MTA have highlighted differences in chemical composition and ultrastructural structure. Bio-C Repair is mainly composed of carbon (34.81%) and oxygen (34.51%), with lower calcium content compared to the calcium-rich formulations of Biodentine and ProRoot MTA.[9]

CONCLUSION

Teeth restored with MTA or Biodentine as root-end filling materials showed greater fracture resistance compared to those treated with Bio-

C Repair. The use of Bio-C Repair as a retrofilling material did not improve the fracture strength of root canal-treated teeth.

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