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6. Clearance	☐ Paper ☑ Article ☐ Book ☐ Presentation ☐ Other
7. Title	Surface Integrity of Orthograde MTA Obturation Following Targeted Endodontic Microsurgery
8. Intended Publication/Meeting	Journal of Endodontics, International Endodontic Journal
9. Required by	10. Date of Submission

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THESIS APPROVAL PAGE FOR MASTER OF SCIENCE IN ORAL BIOLOGY

Title of Thesis: "Surface Integrity of Orthograde MTA Obturation Following Targeted Endodontic Microsurgery"

Name of Candidate: Jason Michael Umbach

Master of Science Degree

THESIS/MANUSCRIPT APPROVED: DATE:

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Learning to Care for Those in Harms' Way

Surface Integrity of Orthograde MTA Obturation Following Targeted Endodontic Microsurgery

Jason M. Umbach, DMD, Matthew B. Phillips, DMD, Joseph M. Dutner, DMD, Scott W. Otterson, DMD, MS, Joshua Jones, DMD

Abstract

Introduction: Guided endodontic microsurgery may be performed utilizing trephine burs for apical root resection. The purpose of this project was to determine if the use of trephine burs in Targeted Endodontic Microsurgery (TEMs) disrupts the MTA fill within the canal.

Methods: 20 maxillary anterior roots were cleaned, shaped, and obturated with MTA. Each root was secured in a custom surgical guide using polyvinylsiloxane material and fastened to a benchtop vice. With continuous water irrigation, roots were resected with either guided trephine burs or multipurpose burs. Resected root ends were analyzed using a dental operating microscope and light microscopy with various fluorescent filters and magnifications up to 40x.

Results: No groups had any detectable defects that could be identified by light microscopy analysis. No significant differences between the multipurpose group and the trephine group were observed.

Conclusion: Analysis of the samples supports the use of trephine burs in guided apical surgery when the root has previously been filled with MTA. No difference could be observed between the groups in regards to disrupting the MTA fill within the canal.

Introduction:

A variety of circumstances can either prevent healing or promote periapical bone loss after conventional endodontic treatment. These factors can be iatrogenic, anatomic, or microbial (biofilms or extraradicular bacteria) and can often include restorative or apical microleakage (1). The surgical removal of root ends, or root-end resection, is a treatment for teeth that have undergone non-surgical root canal therapy without a successful resolution of the apical pathosis. The goal is to eliminate periapical pathologic tissues and irritants contained in the apical portion of the canal in order to promote healthy tissue regeneration. By removing the last 3-4mm of the root, one can eliminate a majority of accessory canals and other apical ramifications where resistant bacteria may reside (2).

Apical surgery continues to evolve with the development of new equipment, materials, instruments, and techniques. Surgical operating microscopes, ultrasonics, biocompatible materials, and 3-dimensional imaging are among the advances over recent years. These developments have led to the success rates of endodontic root-end surgery reaching over 90% (3). Despite these outcomes, anatomical challenges and restrictive access to the root-end deter many endodontists from tackling more challenging cases (2).

Mineral trioxide aggregate (MTA) has several desirable properties in terms of its biocompatibility, bioactivity, hydrophilicity, radiopacity, sealing ability, and low solubility. The most important of these properties in dentistry are its biocompatibility and sealing ability (4). High biocompatibility encourages optimal healing responses. This has been observed histologically with the formation of new cementum in the periradicular tissues (5). Its advantageous seal is likely due to its expansion and contraction properties, which are very similar to dentin, resulting in high resistance to both marginal leakage and bacterial migration into the root canal system (4).

Obturating the root canal system with MTA prior to surgical treatment can provide important advantages. When surgical access is compromised by anatomic structures, this protocol may lessen the technical demands on the operator. It can also mitigate patient management concerns by significantly decreasing the time needed for treatment.

In 2007, Pinsky et al. introduced a novel periapical surgical method using CBCT and CAD/CAM surgical guides (6). CBCT-designed surgical guides allow for more accurate surgical access in endodontic surgery compared with CBCT-approximation freehand methods (6,7). Utilizing a guide also decreases surgical time and the size of the osteotomy (8). Giacomino et al. described a technique they termed targeted endodontic microsurgery (TEMS) in which root end resection is performed utilizing a 3-dimensionally printed guide directing a surgical trephine bur (9). Since the cutting action of trephine burs is different from currently utilized instruments, the mechanical effects of this technique on MTA root filling are currently unknown. A stable barrier to bacterial and fluid leakage is one of the key factors which facilitates MTA clinical success (10). The purpose of this research was to evaluate the effects of a trephine bur on the previously placed MTA root filling.

Materials and Methods:

Extracted human maxillary anterior teeth were collected with patients' consent under a protocol (18-03956/904077) approved by the Dwight D. Eisenhower Army Medical Center Institutional Review Board. Teeth were stored in a phosphate buffered saline. Crowns were sectioned from the roots with a double-sided diamond disc. Microscopic evaluation of the roots ensured no roots with suspected cracks or surface defects were included from the study. Twenty roots were divided into two groups. Each group consisted of 10 maxillary anterior roots (n=10). Group 1 served as the control group in which the roots were resected with a multipurpose bur (Dentsply Maillefer, Ballaigues, Switzerland) while Group 2 was the experimental group in which roots were resected with the guided 5.1 mm trephine burs (BIOMET 3i, LLC, Palm Beach Gardens, FL) at 1,000 rpm.

Utilizing a dental operating microscope, non-surgical root canal therapy was completed on all roots. The working lengths were recorded by visually placing a size 10 K-file until visualized at the apical foramen and then subtracting 1mm. Roots were wrapped in saline soaked gauze when handled. Root canals were cleaned and shaped using Vortex Blue (Dentsply Sirona, York, PA) rotary files utilizing a crown-down technique to file size 50/04. Irrigation with 8.25% sodium hypochlorite between each successive file and a final rinse of 5ml 17% EDTA and 5ml 8.25% NaOCl was performed in each canal. Following cleaning and shaping, each canal was obturated using grey ProRoot MTA (Dentsply Sirona, York, PA). Following non-surgical treatment, the roots were stained with methylene blue dye (Roydent, Johnson City, TN) and a dental operating microscope was used to inspect for any cracks or dentinal defects sustained during instrumentation and obturation. Roots were radiographed during and after obturation to ensure a dense fill free of voids. Roots were stored in phosphate buffered saline for 28 days to ensure a complete set of MTA.

A custom jig was designed to include a three-dimensionally printed surgical guide fabricated in conjunction with the Army Dental Laboratory at Fort Gordon, Georgia (Fig. 1). Roots from both groups were secured within the guide using polyvinyl siloxane (PVS). The guide was manufactured to split along its vertical dimension allowing the teeth to be removed easily. The two halves of the guide were fastened together with a benchtop vise (Fig 2).

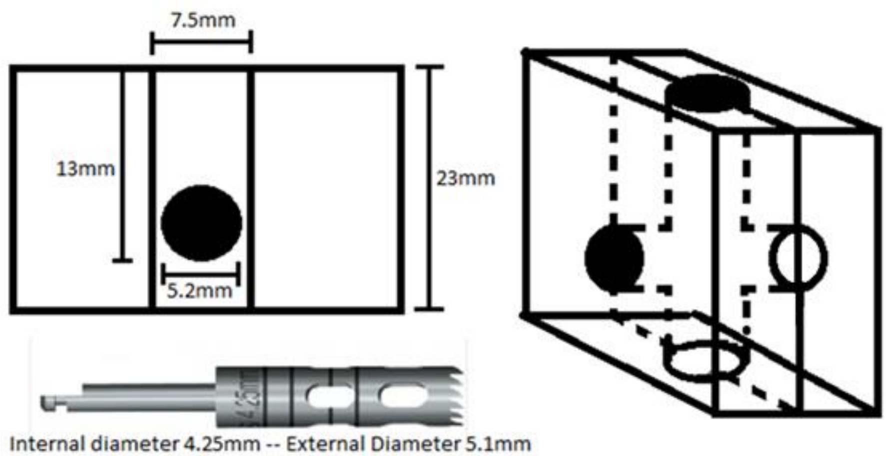

FIGURE 1. Custom jig design measurements.

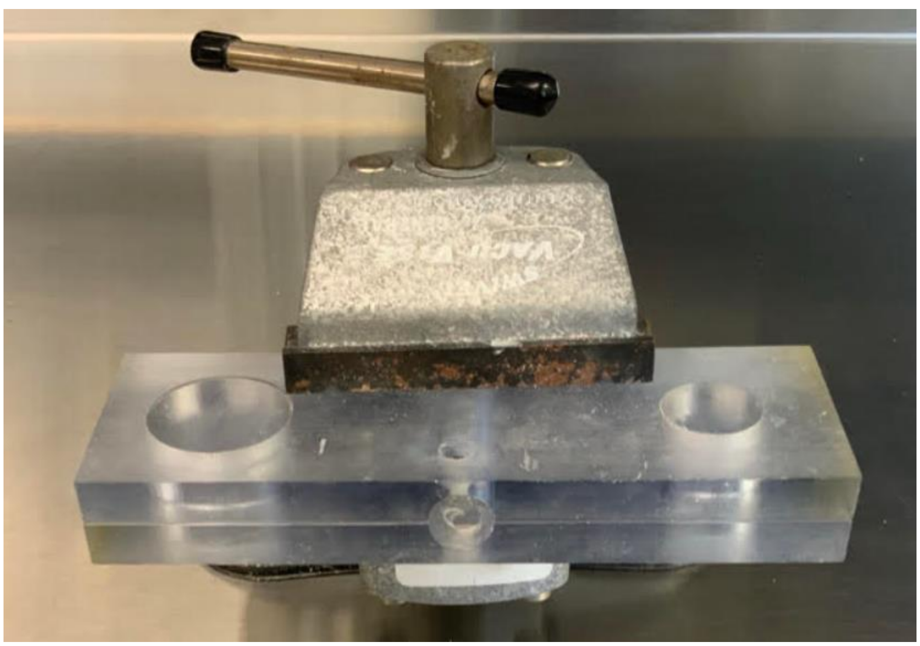

FIGURE 2. Custom jig secured with vise.

Group 1 control roots were sectioned using a multipurpose bur with continuous water spray. Burs were premeasured based on parameters of the surgical guide to ensure a complete resection. The resection was completed with a single pass of the multi-purpose bur in a mesial-distal direction to create a level plane. No additional smoothing was performed. Group 2 experimental roots were resected using a 5.1mm diameter trephine bur utilizing an electric handpiece (W&H, Dental Werk Bürmoos GmbH, Austria) rotating at 1000 rpm with maximum torque and continuous water irrigation. The root ends were resected buccal to lingual with a gentle pecking motion as described by Giacomino et al. (7). Following each resection, the root was removed from the PVS material and immediately placed in phosphate buffered saline until they were analyzed. Analysis began immediately after all roots were resected.

Data Collection

Root ends were observed with a multi-channel fluorescence and transmitted light microscope imaging system (Evos FL, Life Technologies, Carlsbad, CA). Analysis included 4x, 10x, 20x, and 40x magnification with different fluorescent light cube positions in an attempt to identify any disruption of the MTA including defects of the MTA-dentin interface, open margins, and ditched margins.

Results

No groups had any detectable defects that could be identified by light microscopy analysis (Table 1). No significant differences between the multi-purpose group and the trephine were observed. The entire canals were filled with MTA without noticeable gaps at the MTA-dentin interface. Pitting or chipping within the MTA could not be identified in any sample. Due to lack of findings, no statistical analysis was performed.

TABLE 1. Disruption of MTA following resection

Burs	n	%
MultiPurpose Bur (n=10)	0	0
Trephine Bur (n=10)	0	0
Total (n=20)	0	0

Discussion

The custom jig used in this study attempted to replicate an in vivo environment where the roots would only have physiologic mobility while providing a surgical guide for the bur to cut with minimal deviation. The PVS material used in this study did not limit the cutting efficiency of the trephine bur and provided adequate stability to the root during resection. One limiting factor in the model was the absence of a lesion as would be common in most clinical scenarios; however, in order to stabilize the root within the guide, PVS material needed to fully encompass the root. This method was chosen to enable reproducibility within the study, ruling out variables such as bone loss and lesion size.

Using the light microscope for observation had limitations. Even at 40x magnification and the aid of a fluorescent light filter to reduce white light exposure, it was difficult to see imperfections within the MTA like pitting and chipping since the MTA is not translucent. The observations were strictly made at the dentin-MTA interface. Adaptation of the MTA to the canal walls appeared seamless following resection with both the multi-purpose and trephine burs. The use of a scanning electron microscope would have been a superior technique for observation; however, due to the timing of the Covid-19 pandemic, the use of the SEM at our facility was not available.

Initially, 40 roots were resected, 20 maxillary anterior roots and 20 posterior roots. Following the microscope analysis of the anterior roots and prior to analysis of the posterior roots, the light microscope computer crashed and was unable to be repaired prior to the research completion deadline. Having additional roots may have increased the strength of the findings and expanded the scope to different anatomical roots.

One distinct difference with the resection produced by the trephine bur was the concave surface that is created due to the bur’s cylindrical shape. This may expose additional dentinal tubules at the periphery of the root surface. The significance of this difference and whether it poses a threat to long term success is unknown. Future studies may be performed to inspect these areas for residual biofilms. If desired, the root surface can be smoothed following the initial resection. Based on our results, the concave surface did not have an effect on the MTA-dentin interface.

Conclusion

Under the conditions of this study, there was no significant difference in defects at the MTA-dentin interface following root end resections utilizing either multipurpose burs or trephine burs. The results of this study support the use of guided trephine burs in endodontic microsurgery for root end resections of teeth previously root filled with MTA.

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