Retractability of 2 Mineral Trioxide Aggregate–based Root Canal Sealers: A Cone-beam Computed Tomography Analysis

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Abstract

Introduction: The retractability of recent calcium silicate or mineral trioxide aggregate (MTA) sealers has not yet been assessed. The aim of this study was to evaluate the removal of 2 MTA-based sealers (MTA Fillapex [Angelus Soluções Odontológicas, Londrina, PR, Brazil] and MTA Plus [Prevest-Denpro, Jammu City, India]) using a rotary retreatment system, considering an epoxy resin sealer (AH Plus [Dentsply Maillefer, Ballaigues, Switzerland]) as the standard for comparison. Methods: Root canals in 45 single-rooted teeth were instrumented using a rotary nickel-titanium system (MTwo; VDW GmbH, Munich, Germany) and obturated with gutta-percha using one of the following sealers ($n = 15$): group 1, MTA Fillapex; group 2, MTA Plus; and group 3, AH Plus. The teeth were scanned using a cone-beam computed tomography scanner. After 2 months, the root canals were retreated with a rotary retreatment system (ProTaper Universal Retreatment; Dentsply Maillefer, Ballaigues, Switzerland) and a second cone-beam computed tomography scan was performed to assess the amount of remaining root filling material (in percentage) and dentin removal (in cubic millimeters). The time taken to reach the working length was calculated in minutes. Group comparisons were performed using 1-way analysis of variance and the Student-Newman-Keuls post hoc test ($P = .05$). Results: There was a significant difference in the amount of remaining root filling material between the 3 groups ($P < .05$), with group 1 showing the least amount of root filling material ($1.8\% \pm 0.22\%$) and group 3 showing the highest ($10.4\% \pm 0.71\%$). The amount of dentin removal and the time taken to reach the working length was significantly higher in group 3 than in groups 1 and 2 ($P < .05$). There was no significant difference between groups 1 and 2 in these outcome variables ($P > .05$). Conclusions: The rotary retreatment system evaluated was not able to completely remove any of the sealers. MTA Fillapex showed less remaining root filling material than MTA Plus. (J Endod 2013;39:893–896)

Key Words

Calcium silicate, computed tomography, cone-beam computed tomography, mineral trioxide aggregate, retreatment, root filling, sealer

Non-surgical revision of endodontic treatment (orthograde retreatment) aims at complete removal of root canal filling material to regain access to the apical foramen in order to facilitate cleaning and shaping of the root canal system. Several cross-sectional epidemiologic studies have shown radiographic signs of apical periodontitis in root-filled teeth, thereby indicating the need for the revision of root canal treatment (1, 2).

Gutta-percha in conjunction with sealers is the most common root filling material (3). More recently, calcium silicate–based materials such as mineral trioxide aggregate (MTA)–based sealers have been developed, and these materials have been claimed to be biocompatible, to stimulate biomineralization, and to offer a superior seal (4). Furthermore, these materials have been shown to exhibit better bond strengths to dentin than zinc oxide–eugenol–based cements (5) and a sealing ability similar to epoxy resin–based sealers (6). There are also indications for obturating the entire canal with MTA-based materials (7, 8).

MTA Fillapex (Angelus Soluções Odontológicas, Londrina, PR, Brazil) is a 2-paste resin sealer that contains MTA, salicylate resin, natural resin, bismuth, and silica. MTA Plus (Prevest-Denpro, Jammu City, India) is a calcium silicate–based material that is available as a powder-liquid formulation. This material has a finer particle size than other commercially available versions of MTA (50% of the particles finer than 1 $\mu$m). A salt-free water-soluble gel is provided as the mixing vehicle to improve the washout resistance of the material (9). Although studies have been performed that address the removal of gutta-percha and zinc oxide–eugenol and resin sealers, no study has addressed the removal of MTA-based sealers from root canals. This is important considering the widespread use of MTA-based materials in contemporary endodontics because of its ability to undergo biomineralization (10–12). Because MTA-based materials are known to be hard upon setting (13), the ability to retreat canals obturated with these sealers is an area of concern that needs to be addressed.

The aim of this study was to evaluate the retractability of 2 MTA-based sealers (ie, MTA Fillapex and MTA Plus) using cone-beam computed tomography (CBCT), considering an epoxy resin sealer (AH Plus; Dentsply Maillefer, Ballaigues, Switzerland) as the standard for comparison. The null hypothesis was that there is no significant difference in the removal of these materials from the root canal system.
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Materials and Methods
Specimen Preparation and Root Filling

Human single-rooted maxillary canines (N = 45) were collected and thoroughly cleaned by removing the hard deposits using curettes and the soft deposits by soaking in 5.25% NaOCl for 10 minutes. This was done as a routine protocol to disinfect the teeth for operator safety. The teeth were decoronated at the cementoenamel junction using a diamond disc under water cooling. The root lengths were standardized to 17 mm. The teeth were radiographed (DSX 730; Owandy Dental Imaging, Champs sur Marne, France; and Kodak 2100 X ray unit, Kodak Dental Systems, Atlanta, GA) at different angulations to confirm the presence of a single canal. The working length was established using a size 10 K-file (Mani Inc, Tochigi, Japan) to the root canal terminus and subtracting 0.5 mm from this measurement. The root canals were instrumented using MTwO nickel-titanium rotary instruments (VDW GmbH, Munich, Germany) up to size 35/0.06 taper. Irrigation was performed using a 5-mL disposable plastic syringe (Ultradent Products Inc, South Jordan, UT) with a polypropylene capillary tip (Ultradent) placed passively into the canal, up to 2 mm from the apical foramen without binding. Irrigation was performed applying 5 mL 3% sodium hypochlorite during instrumentation. After this, all specimens were irrigated with 5 mL 17% EDTA for 2 minutes. Canals were rinsed with 5 mL distilled water and dried using paper points (Dentsply Maillefer).

The roots were inserted into moistened foam to simulate the soft tissues and randomly divided into 3 groups (n = 15) based on the material used for obturation: group 1 (gutta-percha with MTA Fillapex), group 2 (gutta-percha with MTA Plus), and group 3 (gutta-percha with an epoxy resin sealer [AH Plus]). The root canals were dried with sterile paper points and obturated with gutta-percha and sealer using the lateral compaction technique. A standardized gutta-percha master cone size 30 was fitted with tug back at the working length. The sealers were introduced into the canal using a Lentulo spiral (DentsplyMaillefer). Cold lateral compaction with accessory gutta-percha cones size 15 was performed until these could not be introduced more than 5 mm into the root canal. The excess gutta-percha was removed with a heated plugger to ensure a standardized length of the root fillings (15 ± 1 mm). Subsequently, the quality and apical extent of the root canal filling followed by the D2 ProTaper instrument (size 20/0.07 taper) was used to the working length. Apical preparation was performed with ProTaper instruments F2 (size 25/0.08 taper), F3 (size 30/0.09 taper), and F4 (size 40/0.06 taper).

Apical preparation was performed with ProTaper instruments F2 (size 25/0.08 taper), F3 (size 30/0.09 taper), and F4 (size 40/0.06 taper). Final irrigation was performed with 5 mL 17% EDTA (Pulpdent, Watertown, MA) and 5 mL 3% NaOCl (Prime Dental Products, Mumbai, India), and root canals were dried with paper points. All instruments were used only for 1 specimen, and the removal of filling materials was judged complete when the working length was reached and no more filling material could be seen on the last instrument used. A second CBCT scan was performed, and the volume of the remaining material in each tooth was estimated as mentioned earlier. The time required to retreat each canal was also recorded. Pre- and postoperative volumes of the root filling material and dentin were measured (in cubic millimeters) by 2 blinded observers, and the mean values for each specimen were calculated. The mean percentage of residual filling material and the mean amount of dentin removal during retreatment procedures were calculated.

Data Presentation and Analysis. The mean residual filling material was expressed as percentage (± standard deviation) values of the total filling material, and the time used to reach the working length was expressed in minutes (± standard deviation). The mean dentin removal was expressed in cubic millimeters (± standard deviation). Group comparisons were performed using 1-way analysis of variance and the Student-Newman-Keuls post hoc test. The alpha-type error was set at 0.05 for all statistical analyses.

CBCT Scans

All the teeth were scanned by a CBCT scanner (i-CAT; Imaging Sciences International, LLC, Hatfield, PA) with constant thicknesses of 125 μm/slice. The teeth were viewed both cross-sectionally and longitudinally. Volume rendering and multiplanar volume reconstruction were performed to calculate the volume of root filling material.

Results

Residual Root Filling Material

The percentage of residual root filling material was lowest in group 1 (1.8% ± 0.22%), which was significantly less than in the other 2 groups (P < .05). Group 3 showed a significantly higher percentage of remaining root filling material (P < .05) (Table 1).

Dentin Removal

The amount of dentin removed in samples of group 3 was significantly higher than in group 1 (P < .05), whereas this difference was not significantly different from group 2 (P > .05) (Table 1).

TABLE 1. Means and Standard Deviations for Residual Root Canal Filling (in %) and Dentin Removal (in mm³) and the Time Taken to Reach the Working Length (in minutes) for Each Group (n = 15)

<table>
<thead>
<tr>
<th>Group</th>
<th>Residual root filling material</th>
<th>Dentin removal</th>
<th>Time taken to reach working length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.8 ± 0.22a</td>
<td>5.7 ± 0.73b</td>
<td>5.5 ± 0.55a</td>
</tr>
<tr>
<td>2</td>
<td>6.0 ± 0.65c</td>
<td>12.9 ± 1.11b</td>
<td>6.0 ± 0.65c</td>
</tr>
<tr>
<td>3</td>
<td>10.4 ± 0.71c</td>
<td>13.7 ± 1.2b²</td>
<td>6.85 ± 0.51b</td>
</tr>
</tbody>
</table>

Mean values that share a superscript letter were not significantly different at the 5% level within the same root third (1-way analysis of variance and the Student-Newman-Keuls post hoc test).
The time taken to reach the working length in the groups restored with gutta-percha and MTA-based sealers was significantly less than the time taken to reach the working length in the group obturated with gutta-percha and epoxy resin sealer \( (P < .05) \). However, there was no statistically significant difference in the time taken to reach the working length between groups 1 and 2 \( (P > .05) \) (Table 1).

**Discussion**

The causes for persistent periapical disease after root canal treatment include necrotic tissues, bacterial biofilms, coronal leakage, recurrent caries, and tooth fractures (14). To re-establish an environment conducive to repair and healing, these etiologic factors must be removed. Immaterial of the etiologic factor, nonsurgical root canal treatment requires removal of the root filling material present in the root canal system (15).

This study evaluated the retreatability of 2 MTA-based sealers using CBCT scanning, considering an epoxy resin sealer (AH Plus) as the standard for comparison. The method used to evaluate the filling remnants plays an important role in the results obtained in each study. Previous studies on retreatability of root filling materials involved longitudinal sectioning of teeth followed by either digital imaging of surfaces or scanning electron microscopic analysis. However, these methods are 2-dimensional and do not offer accurate measurement of the root filling remaining inside root canals.

Recently, microCT (microCT) has been used as a research tool in endodontics for studying root canal anatomy (16), the assessment of root canal preparation techniques (17), the efficacy of obturating methods, and the removal of root filling materials (18). However, microCT is not suitable for clinical use, and it is imperative to evaluate methods of removal of root filling materials using a technique that can show accuracy similar to microCT yet is clinically feasible. A recent study showed that only high-resolution CBCT instruments allow dentists to detect the full length of the root canal and, hence, can be suggested as a clinical alternative to microCT (19). It has also been established that CBCT scanning is more accurate than other forms of CT, namely spiral CT and peripheral quantitative computed CT (20, 21). To the best of our knowledge, this is the first study to use CBCT scanning to study the retreatability of MTA-based root filling materials.

The results of this study showed that none of the root filling materials could be removed completely. This is in accordance with previous studies (15, 22, 23). In the present study, the removal of MTA Fillapex consumed the least amount of time followed by MTA Plus and AH Plus. Furthermore, the least amount of remaining root filling material after retreatment was observed with MTA Fillapex; this was significantly less than the other groups. This may be attributed to 2 reasons: the low bond strength of MTA Fillapex to root dentin and the questionable biomineralization of MTA Fillapex. The low bond strength of MTA Fillapex confirms the results of 2 recent studies that reported a low adhesion capacity of MTA Fillapex (24, 25). The concept of biomineralization demands more explanation. The superior performance widely reported by the literature for the use of MTA was recently attributed to its biomineralization ability. The interaction of MTA with a phosphate-containing fluid produces calcium-deficient B-type carbonated apatites via an amorphous calcium phosphate phase. The apatite formed by the MTA-PBS system deposits on the collagen fibrils, thereby triggering the formation of an interfacial layer with tag-like structures at the MTA-dentin interface. Furthermore, this biomineralization process is claimed to enhance the resistance to the dislodgement of MTA from dentin (10–12). However, the low bond strength of MTA Fillapex has been attributed to the low adhesion capacity of these tag-like apatites (24). However, this supposition is in contrast to the findings of Salles et al (26), who noted that MTA Fillapex showed increased alkaline phosphatase activity after 7 days, thereby stimulating hydroxyapatite crystal nucleation. Nevertheless, a comparison of MTA Fillapex with other commercial brands of MTA is yet to be performed.

MTA is a bioactive material that can form a layer of hydroxyapatite or carbonated apatite on its surface when it comes in contact with a phosphate-containing fluid for 2 months. Formation of this interfacial layer develops a chemical bond between MTA and dentinal walls (27). A previous study showed that the greatest mean bond strength values were observed after exposure of MTA to a pH of 8.4. At this pH level, MTA showed higher surface hardness as well as less porosity (28). Therefore, samples were exposed to PBS at a pH of 8.4 for a period of 2 months to bring about biomineralization (29). MTA Plus is a material that presents basically the same composition of the original MTA formulation, whereas MTA Fillapex is mainly composed of a combination of resins, silica, and MTA. The total content of MTA in Fillapex is only 13.2%. Whether this quantity of MTA is substantial enough for inducing biomineralization equivalent to MTA Plus, which is 100% MTA, may be questioned. This may be further evidenced by recent works that have shown that MTA Fillapex showed a significantly inferior sealing ability than ProRoot MTA and AH Plus (30). Further analysis of the interface is needed to determine the mechanism of bioactivity of these sealers.

**Conclusions**

Under the conditions of the present study, it was impossible to completely remove the root filling materials from the root canal systems. The least remaining root filling material was demonstrated by MTA Fillapex.

**Acknowledgments**

The authors deny any conflicts of interest related to this study.

**References**


