Comparison of Gap Volume after Retrofilling Using 4 Different Filling Materials: Evaluation by Micro–computed Tomography

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Abstract

Introduction: The purpose of this study was to evaluate the gap volume between dentin and root-end filling materials. **Methods:** Four root-end filling materials were compared in the present study: ProRoot MTA (PRM; Dentsply Tulsa Dental, Tulsa, OK), MTA Angelus (MAG; Angelus, Londrina, Brazil), EndoCem MTA (ECM; Maruchi, Wonju, Korea), and RetroMTA (RTM; BioMTA, Seoul, Korea). Forty-eight single-rooted, extracted human teeth were instrumented with nickel-titanium instruments and oburated with gutta-percha. The apical 3 mm of the root tip was resected, and root-end preparation was performed with a diamond bur. The root-end cavity was filled with the experimental filling materials for the 4 designated groups (n = 10). Then, the samples were scanned with micro–computed tomographic (micro-CT) imaging. Three-dimensional images of the samples were reconstructed, and the volume of the gap between the tooth surface (dentinal wall) and the root-end filling materials was measured. The percentage volume of the gap between the tooth structure and the root-end filling material (V_G%) was calculated. Data were analyzed using the Kruskal-Wallis and Mann-Whitney U tests at a significance level of 95%. **Results:** The median V_G% values for the PRM, MAG, ECM, and RTM groups were 0.00472, 0.00134, 0.00014, and 0.00071, respectively. The ProRoot MTA group showed the greatest gap volume percentage among the experimental groups with a significant statistical difference (P < .05). **Conclusions:** From the micro-CT analysis, ProRoot MTA had a greater gap volume percentage than other root-end filling materials. *(J Endod 2017;■ :1–4)*

Key Words

Gap, leakage, micro–computed tomography, mineral trioxide aggregate, root-end cavity, root-end filling, scanning electron microscope, surgical endodontics

Significance

Root-end filling materials have different ranges of gap volume between retrofilling materials and the surrounding dentin.

Since the introduction of mineral trioxide aggregate (MTA) in the 1990s, many studies have evaluated and investigated its characteristics and reported its superior sealing ability (1, 2) and biocompatibility (3, 4). Nonetheless, there are some commonly found drawbacks of MTA, namely, its slow setting time and difficulties in handling and manipulation of the materials (5, 6).

The slow setting time of MTA can lead to the questionable integrity and possible washout of MTA when it is used in the clinical microsurgery setting as a root-end filling material (5, 6). In addition, the handling and manipulation of MTA often cause difficulties for clinicians because of its granular consistency (6), looseness (7, 8), and inability to be easily carried and delivered (9). To overcome these shortcomings of MTA, many attempts were made by numerous scholars including the addition of various accelerants (7, 10, 11), modification in the formula (7, 12), the use of antiwash gel (13), and the invention of the delivery system (9).

Recently, new types of materials for root-end filling became available to overcome the shortcomings of MTA. A pozzolan cement (EndoCem MTA [ECM]; Maruchi, Wonju, Korea) was introduced in the market; ECM is a fast-setting cement that is similar to MTA but has small particles of pozzolan cement (14). Another newly developed material is RetroMTA (RTM; BioMTA, Seoul, Korea). According to the manufacturer, it is similar to MTA but has the addition of the calcium zirconia complex to enhance the properties and a rapid setting time of 150 seconds. Because both of them are fairly new products in the dental market, to date, not many studies have reported on the properties of these products.

In surgical endodontic treatment, not only surgical removal of the irritant but also prevention of egress of any remaining irritant from the root canal system into the periapical tissues is essential. To prevent outgrowth of bacteria, an ideal root-end filling material should have dimensional stability, minimization of gap volume between the dentinal wall and root-end filling material, and closure of microleakage to promote periapical tissue healing (1). Therefore, the purpose of this study was to evaluate and compare the gap volume between the dentin and the root-end filling materials using micro–computed tomographic (micro-CT) analysis.

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Materials and Methods

Sample Preparation

Four experimental root-end filling materials were used: ProRoot MTA (PRM; Dentsply Tulsa Dental, Tulsa, OK), MTA Angelus (MAG; Angelus, Londrina, Brazil), RTM, and ECM. Forty-eight single-rooted, extracted human teeth were collected and stored in buffered saline (PBS 3813; Sigma-Aldrich, St Louis, MO) in a refrigerator until use. Any teeth with previous root canal treatments, cracks, or perforations were excluded from the experiment. The roots were randomly assigned to 4 groups according to the retrofilling materials (n = 12).

The canals were instrumented with the ProTaper nickel-titanium instrument system (Dentsply Maillefer, Ballaigues, Switzerland) to a master apical size of #40 (F4) in a crown-down fashion and 0.5 mm short of the apical foramen. The canals were irrigated using sodium hypochlorite in a common clinical way. After a final irrigation using EDTA, they were obturated with gutta-percha (Obtura III Max System; Obtura Spartan, Fenton, MI). Then, the root tips (3 mm from the apex) were resected at 90° to the longitudinal axis of the teeth with a tapered diamond bur (ISO 173/016 Fine; MANI, Tochigi, Japan). A root-end cavity of 3-mm depth was prepared with another tapered diamond bur (ISO 160/014 Extra Fine, MANI). To standardize for uniformity of the length and size of the retropreparations, efforts were made to insert the burs about 3 mm into the canals and to keep the size of the preparation the same as the size of straight apical pluggers, which are commonly used in endodontic microsurgeries.

The retrofilling materials were mixed and applied according to the manufacturers' instructions in an order of 1 by 1 from each group. All apicoectomy procedures were performed under a dental microscope (OPMI PICO; Carl Zeiss, Göttingen, Germany) at 10× magnification. After root-end fillings were done, radiographs were taken for all samples to ensure the quality of filling. The retrofilled samples were allowed to set and stored in an incubator (37°C, >95% relative humidity) for 7 days. All specimens were prepared by 1 operator who was a third-year resident in the endodontic department.

Micro-CT Evaluation

To evaluate the sealing ability of the root-end filling materials, the gap between the tooth surface and the root-end filling material was examined using micro-CT imaging (Skyscan 1076; SkyScan, Kontich, Belgium). The gaps for the 4 experimental groups of retrofilling materials were measured with an x-ray source voltage of 100 kV, a beam current of 100 μA, a 0.5-mm-thick Al filter, a rotation step of 0.5 step, a pixel size of 9 μm, and an exposure time of 4712 milliseconds. After the micro-CT images were taken, 2 software programs (NRecon v1.6.3.2 and ct_An, SkyScan) were used to reconstruct 3-dimensional (3D) images of the samples and to measure the volume of the gap between the tooth surface and the root-end filling materials. Micro-CT scanning and 3D image reconstruction analysis were performed by 1 technician.

After micro-CT scanning, the range of measurement was set to be 2 mm coronal from the resected apex for measuring the volume of the gap between the tooth surface and the root-end filling materials. Within that range, a density between 80 and 255 was assigned to be the volume of root-end filling material (V_M), and a density between 0 and 23 was assigned to be the volume of the gap (V_G). Micro-CT scans were reconstructed to 3D images (Fig. 1*A–D*) using the NRecon software program. The gray portion is the root-end filling material, and the blue dots represent the gap between the root-end filling and the tooth structures. V_M and V_G were acquired using the ct_An program. Then, the percentage volume of the gap between the tooth structure and the root-end filling material (V_G%) was calculated using the following formula: $V_G\% = V_G/(V_M + V_G)$.

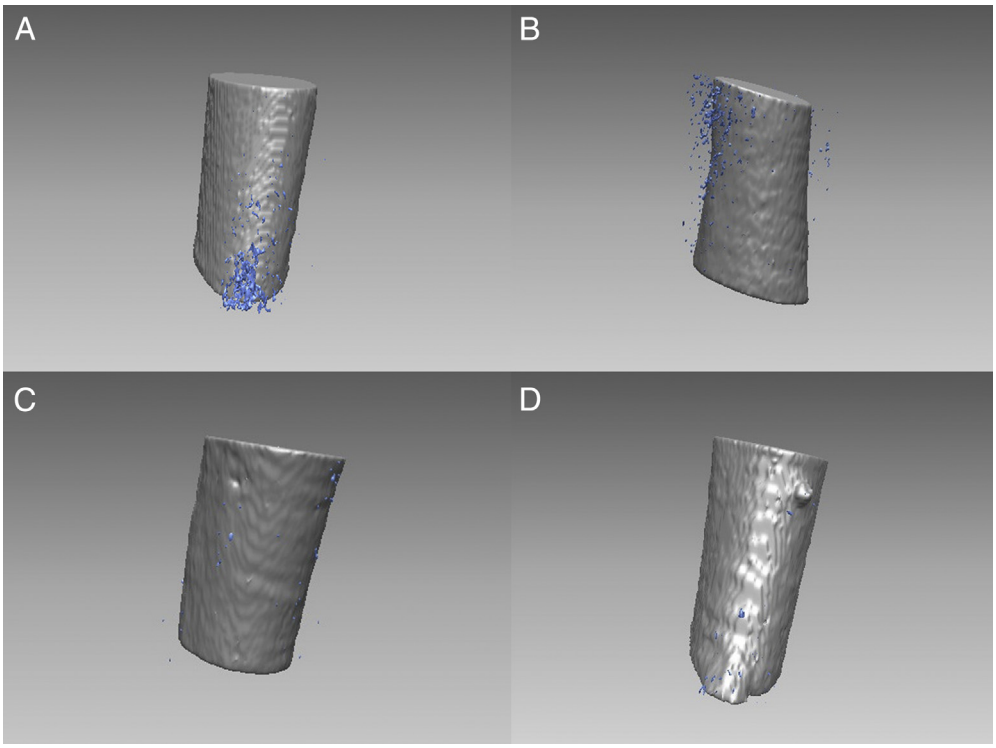

Figure 1. Representative 3D images from micro-CT scans. (*A*) PRM, (*B*) MAG, (*C*) ECM, and (*D*) RTM groups. The *gray cylinder shapes* represent the filling materials, and the *blue dots* represent the gap around the root-end fillings. *A* and *B* show relatively larger clusters of *blue dots*, which implicate bigger gaps than *C* and *D*.