Root Canal Filling Quality of a Premixed Calcium Silicate Endodontic Sealer Applied Using Gutta-percha Cone-mediated Ultrasonic Activation

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Abstract

Introduction: The aim of this study was to investigate the filling quality of a recently developed premixed calcium silicate–based endodontic sealer (Endoseal MTA) with a single gutta-percha (GP) cone technique compared with a resin-based sealer (AH plus) with warm vertical compaction. We also explored the effect of GP cone-mediated ultrasonic activation on the filling quality of Endoseal MTA. **Methods:** Thirty human single-rooted maxillary premolars with ribbon-shaped canals were prepared and assigned to 3 experimental groups according to filling method: EMS group was Endoseal MTA + single-cone; EMSU group was Endoseal MTA + single-cone with ultrasonic activation; and the APW group was AH plus + warm vertical compaction. Each tooth was scanned using micro–computed tomography (μ-CT), and the proportions of sections with void and the volume percentages of void were calculated. Then, the tooth was sectioned transversely, and the presence of void in the slices was scored under a stereomicroscope. The data were statistically analyzed using 1-way analysis of variance and Tukey tests to detect any significance ($\alpha = 0.05$). **Results:** In the μ-CT assessment, there was no significant difference among the groups regarding the proportion of sections with void and the void volume percentage ($P > .05$). However, in the stereomicroscopic evaluation, the EMS group showed a higher number of voids and a higher void score compared with the other groups ($P < .05$). **Conclusion:** Endoseal MTA performs best when used with GP cone-mediated ultrasonic activation. Furthermore, stereomicroscopic observation of sections of the specimens should be performed when evaluating root canal filling quality. *(J Endod 2017;■:1–6)*

Key Words

Calcium silicate, filling quality, gutta-percha, micro–computed tomography, premixed, ultrasonic

Significance

Endoseal MTA, the premixed calcium silicate sealer, is preferred to be used with gutta-percha cone-mediated ultrasonic activation

Calcium silicate cement (eg, mineral trioxide aggregate [MTA]) has been widely used adjacent to pulp and periradicular tissues for perforation repair (1), root-end filling (2), direct pulp capping (3), and regenerative endodontics (4). Some have suggested using calcium silicate cement to obturate the entire root canal system due to its favorable sealing ability and biocompatibility. However, these attempts were limited to particular clinical situations, such as primary teeth (5), 1-visit apexification (6), and internal root resorption repair (7). Furthermore, some studies showed that MTA exhibited significantly lower filling quality than conventional filling technique with gutta-percha (GP) and sealer (8, 9). One possible explanation for the inferior results was that it is difficult to place the cement up to the apical area of the root canal due to handling difficulty (9). Therefore, some studies suggested the use of ultrasonication to improve filling quality (10–12). Ultrasonic activation may generate compressive force that leads to rearrangement of the cement particles, facilitating the escape of entrapped air. However, there is still some discussion regarding the effectiveness of this technique (13, 14).

Recently, calcium silicate paste endodontic sealers, such as Endosequence BC (Brasseler USA, Savannah, GA), iRoot SP (Innovative BioCeramix, Inc, Vancouver, BC), and Endoseal MTA (Maruchi, Wonju, Korea) were introduced in an attempt to overcome the difficulty of placing the cement throughout the root canal space. The sealers are premixed, and they are ready-to-use calcium silicate–based materials that are stored in an air-tight syringe. This permits their direct application into the root canals without mixing. This type of sealer absorbs moisture during the setting reaction, and sets slowly by itself without any mixing procedure. Among these, Endoseal MTA was launched most recently, and it has been investigated more frequently than other mentioned sealers. Previous studies indicated that Endoseal MTA showed satisfactory physical properties (15), biocompatibility (15, 16), good bond strength performance (17), fracture resistance of root dentin (18), minimal discoloration

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(19), and superior sealer distribution (20); conversely, there have been no studies regarding the root canal filling quality of the sealer.

Premixed injectable sealers are designed to be used with a single-cone technique, and several previous studies described the technique in detail (9, 21–25). The single-cone technique is considered to be less operator-dependent and potentially less damaging to the root canal dentin (26). To facilitate obturation, this technique relies on a sealer with good physicochemical properties that allows the sealer to flow and fill any space between the cone and dentin to provide a tight seal (26). In this respect, it is necessary to find a method, such as ultrasonication, to improve the filling quality of the sealers. As a result, the manufacturer of Endoseal MTA has proposed a new method in which ultrasonic power is applied directly to the master GP cone so that the cone transfers energy to the pre-placed sealer to achieve better filling quality with fewer voids (Fig. 1). Previously, Hwang et al. (20) used this technique to fill the canal with Endoseal MTA, and they reported favorable results regarding sealer distribution and bacterial leakage. In this respect, the aim of this *ex vivo* study was to investigate the filling quality of Endoseal MTA with a single-cone technique and to compare this method with AH plus vertically compacted with a heated plugger. In addition, the study aimed to explore the effect of the GP cone-mediated ultrasonic application on the filling quality. Additionally, the evaluation was assessed by using micro–computed tomography (μ-CT) scans and stereomicroscopic observation of mechanically sectioned specimens to verify the validity of the methods.

Materials and Methods

Sample Preparation

Thirty intact, caries-free human single-rooted maxillary premolars with ribbon-shaped canals in the cross section were obtained with patient informed consent under a protocol approved by the Institutional Review Board of Chonbuk National University Hospital. Each tooth underwent a μ-CT scan (SkyScan, Kontich, Belgium) to ensure that it contained a ribbon-shaped canal, and the ribbon-shaped canal was prepared containing 2 canals.

After preparing an access cavity, a size 10 K-file (Dentsply-Maillefer, Ballaigues, Switzerland) was inserted into the canal until it was just visible at the apical foramen. The working length was determined by subtracting 0.5 mm from this length. The root canals were instrumented with nickel-titanium reciprocating files (Reciproc; VDW, Munich, Germany) in the presence of a 5.25% sodium hypochlorite (NaOCl) solution. A new instrument was used for the preparation of each tooth to ensure optimal shaping efficacy. After completing the instrumentation, the canal was irrigated with 5 mL of 17% ethylenediaminetetraacetic acid and 5 mL of a NaOCl solution. After shaping and cleaning, the teeth were randomly divided into 3 groups (n = 10) before obturating the instrumented canal spaces.

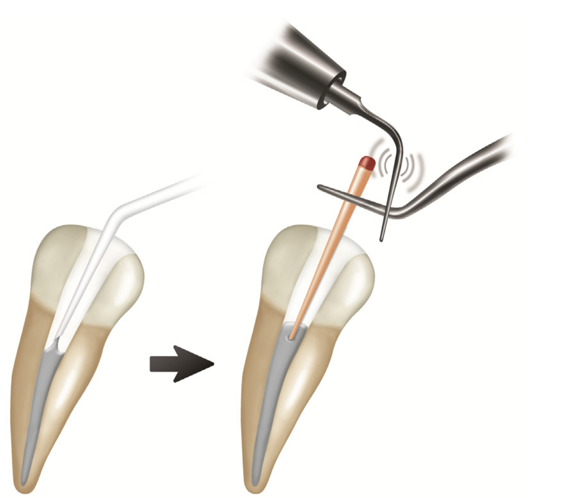

Figure 1. Illustration of gutta-percha cone-mediated ultrasonic activation with Endoseal MTA.

EMS group: Endoseal MTA + single-cone technique: The sealer was dispensed directly into the canal from a premixed syringe via a disposable canal tip. The selected master GP cones (0.04 taper, #25 or 30 size) exhibited good apical tug back, and the cones were slowly inserted into the canals. The excess cone was trimmed off at the canal orifice level and no additional cones were used.

EMSU group: Endoseal MTA + single-cone technique with ultrasonic activation: An ultrasonic tip (StartX #3, Dentsply-Maillefer) was connected to an ultrasonic device (P-5 Newtron XS; Satelec, Mount Laurel, NJ), which was set on "8" in the yellow code (ie, indicated as suitable for endodontics by the manufacturer). After placing the sealer into the canal, ultrasonic vibration was applied to a cotton plier that held the GP cone 20 mm from the tip (Fig. 1). Then, the cone slowly reached the working length during continuous ultrasonic activation. The ultrasonic application time during GP cone placement was 2 to 3 seconds, and the excess cone was cut at the orifice level.

APW group: AH plus + warm vertical compaction technique: Each canal was filled with AH plus (Dentsply DeTrey, Konstanz, Germany) and a GP cone using a warm vertical compaction technique. Briefly, the inserted GP cone was down packed with a Dia-Pen heat source (Diadent, Cheongju, Korea) to within 3 to 5 mm of the working length, and the canal was backfilled using Dia-Gun (Diadent).

The access cavities were filled with a flowable composite resin (G-ænial Flo; GC, Tokyo, Japan), and the teeth were maintained at 100% humidity for 7 days at 37°C to allow the sealer to completely set.

μ-CT Evaluation

A SkyScan 1076 high-resolution μ-CT scanner was used to scan the teeth, and the μ-CT scanner had a pixel size of 30 μm. The X-ray source voltage was 100 kV, the beam current was 100 μA, and the aluminum filter thickness was 0.5 mm. The rotation was 0.4° per step, and the exposure time was 316 ms. To minimize ring artifacts, air calibration of the detector was carried out before each scan. Other settings included the beam-hardening correction and input of optimal contrast limits according to the manufacturer's instructions. Images obtained from the scan were reconstructed using the NRecon (SkyScan) software, and CT-An (version 1.12.9; SkyScan) was used to measure the volume of the void.

The presence of void was assessed in 2-dimensional slices using a previous study's protocol (27). Starting at the apical end of the root, new cross-sectional images were prepared perpendicular to the long axis of the root. The sections had an interval of 50 μm, and the average number of cross-sections was 243. The μ-CT images of the sections were then converted to tagged image file format (tiff) and coded. The presence of void was assessed in each section on a diagnostic screen by 2 observers (Fig. 1*A–D*). The observers were unaware of the root canal filling technique. For each section, measurements were repeated 2 times, and the mean was calculated. Then, the proportion of sections with void was computed for each root.

To calculate the void in the 3-dimensional volumes, the original grayscale images were processed using a Gaussian low-pass filter for noise reduction. An automatic segmentation threshold was used to subtract dentin using CT-An. A thresholding (binarization) process was used