Comparisons of the Retreatment Efficacy of Calcium Silicate and Epoxy Resin–based Sealers and Residual Sealer in Dentinal Tubules

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Abstract

Introduction: The aim of this study was to evaluate the retreatment efficacy and amount of residual sealer in a single canal filled with either EndoSequence BC (Brasseler, Savannah, GA) or AH Plus (Dentsply DeTrey, Konstanz, Germany). **Methods:** Canal obturation with gutta-percha and sealer was performed in 28 human teeth using the continuous wave technique. Group 1 (n = 13) used AH Plus sealer, and group 2 (n = 15) used EndoSequence BC sealer. After 7 days, the root fillings were removed using Gates Glidden drills and a nickel-titanium rotary system. Retreatment time was measured in seconds. Canal cleanliness was examined by scanning electron microscopy. The remaining debris in the canal space and penetration into dentinal tubules were evaluated by confocal microscopy. Retreatment time was compared using the Student t test, and differences in sealer penetration and remaining debris between the groups were analyzed using the Mann-Whitney U test ($P < .05$). **Results:** There was no significant difference between the 2 groups in the amount of dentin penetration, amount of debris, or retreatment time. With respect to penetration depth, the AH Plus group showed a slightly higher percentage than the BC group, with a significant difference only in the portion 6 mm from the apex ($P < .05$). Scanning electron microscopic images showed significant debris remaining on canal walls in both groups, whereas canal patency in retreatment was achieved in every specimen. **Conclusions:** The present study shows that EndoSequence BC sealer and AH Plus sealer have similar efficacy in dentin penetration and retreatment efficacy. *(J Endod 2015;41:2025–2030)*

Key Words

Calcium silicate, dentin penetration, endodontic sealer, retrievability

Recently, calcium silicate–based sealers such as MTA Plus (Prevest Denpro GmbH, Heidelberg, Germany), MTA Fillapex (Angelus, Londrina, Brazil), iRoot SP (Innovative BioCeramix, Vancouver, BC, Canada), and EndoSequence BC (Brasseler USA, Savannah, GA) have been introduced. These products have shown low cytotoxicity, suitable bonding strength, and sealing ability (1–3). Moreover, some materials have been reported to induce biomineralization and hard tissue deposition (4). EndoSequence BC, 1 of the calcium silicate–based sealers, is composed of calcium silicates, calcium phosphate monobasic, zirconium oxide, tantalum oxide, and thickening agents. According to a recent study, EndoSequence BC sealed the root canal better than AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) (5) and showed the highest bond strength under all moisture conditions (6). The material's bond strengths were shown to be significantly higher than those of Sealapex (Kerr, Orange, CA) and EndoRez (Ultradent, South Jordan, UT) (7). Additionally, the material showed marginal adaptation similar to that of MTA (8). Zhang et al (9) reported EnodSequence BC's cytotoxicity at 24 hours was much less than that of AH Plus, and it showed high biocompatibility. Moreover, although zinc oxide eugenol and AH Plus evoked greater calcitonin gene-related peptide release, EndoSequence BC sealer reduced basal calcitonin gene-related peptide release at all concentrations tested, indicating less potential for pain and neurogenic inflammation (10). It was also reported that BC sealer enhanced osteoblastic differentiation of periodontal ligament cells (11), induced dentin remineralization (12), and had strong antibacterial properties (13, 14).

However, although the material's clinical and biocompatibility features show promise in recently performed studies, studies on its retrievability are relatively few, and their results vary significantly. A calcium silicate–based sealer was shown to create hydroxyapatite crystals in the interface between dentin and sealer, and its retrieval from the dentinal wall and dentinal tubules may be challenging. Furthermore, the sealer's ability to penetrate dentin is a property that may be related to the material's retrievability. Although a dentin penetration property is not a shortcoming, the deep penetration depth of the material and dentinal tubule blockage may add challenges to canal retreatment. Only a few studies have focused on the retrievability and dentin penetration of calcium silicate sealers, and their results also vary significantly (15–17).

Therefore, the purpose of this study was to evaluate and compare EndoSequence BC sealer and AH Plus sealer both in removal efficacy and the amount of residual filling material in the canal and dentinal tubules.

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Materials and Methods

Preparation of Tooth Samples

A total of 28 extracted single-rooted mature human teeth were used. The teeth were extracted for orthodontic and periodontal reasons, and the protocol was approved by the institutional review board committee at our institution (institutional review board approval no. 2-2015-0086). Teeth with microcracks were excluded from the study. Tooth crowns were removed using a water-cooled diamond bur to form standardized root samples of 13-mm lengths. K-file sizes #10 and #15 (Dentsply Maillefer, Ballaigues, Switzerland) were inserted into the canal to achieve the working length (WL). The canals were prepared using the ProFile rotary system (Dentsply Maillefer) to a size #35/0.06 taper according to the manufacturer's instructions. Irrigation with a 3.25% sodium hypochlorite (NaOCl) solution was performed using a 27-G needle during filing. Finally, to remove the smear layer, 10 mL 17% EDTA solution was applied for 60 seconds. Then, the canals were flushed with 3.25% NaOCl and dried.

Teeth were divided into 2 groups based on the sealer used during the root filling procedure: group 1 (n = 13) (AH Plus sealer) and group 2 (n = 15) (EndoSequence BC sealer). Both sealers were mixed with rhodamine B (Sigma-Aldrich, St Louis, MO) for fluorescence. Rhodamine B was mixed with sealer at a 1:100 ratio by weight. Both sealers were prepared according to the manufacturers' instructions. In all samples, root canal walls were dried with paper points (#25, Dentsply Maillefer), and then a medium-sized gutta-percha cone (DiaDent, Cheongju-si, Korea) was coated with each sealer and inserted into the root canal. The canal filling process was performed using the continuous wave technique. The access cavities were temporarily sealed with Caviton (GC, Tokyo, Japan), and the teeth were then stored in a humidified chamber (100% humidity and 37°C) for 7 days.

The root fillings were removed with #2, #3, and #4 Gates Glidden drills (Dentsply Maillefer) and ProFile rotary instruments. The rotary instruments were sequentially used in a crown-down manner. Retreatment progressed until a #40/0.06 tapered ProFile reached the WL. The achievement of patency was also recorded for each specimen. The time required to remove the root filling was recorded in seconds. No solvent was used to soften the gutta-percha. The canals were irrigated with 3.25% NaOCl between filings. A single operator performed all root canal instrumentation and retreatment procedures. Teeth without canal filling and teeth without retreatment after canal filling were used as controls.

After these procedures, the canal orifice shapes of all teeth were examined. Microscopic photographs were taken, and the horizontal and vertical diameters of each tooth were measured. The shorter diameter was divided by the longer diameter (%, dS/dL) to determine whether each orifice was round or oval. This procedure was performed to determine whether there was a significant difference in anatomic morphology between the 2 groups.

Retreatment Time

The time required for retreatment was measured and recorded in seconds (n = 12 in the AH Plus group and n = 14 in the BC group). Retreatment time measurement began at the beginning of use of the Gates Glidden drills and ended when a #40/0.06 taper ProFile reached the WL.

Scanning Electron Microscopy

Canal cleanliness after retreatment was examined by scanning electron microscopy (n = 3 for each group). The retreated samples were embedded in clear resin and sectioned longitudinally. All samples were coated with gold by ion sputter (Eiko IB-3; Eiko Engineering Co Ltd, Hitachinaka, Japan), examined, and photographed with scanning electron microscopy (FE SEM S-800; Hitachi, Tokyo, Japan) at an acceleration voltage of 20 kV at various magnifications (25.0–25,000×).

Confocal Microscopy

Teeth were embedded in clear resin and sectioned horizontally 3 mm and 6 mm from the apex at a 100-μm thickness. All samples (n = 10 in the AH Plus group and n = 12 in the BC group) were evaluated under a confocal microscope (LSM 780; Zeiss, Jena, Germany) to calculate the amount of sealer remaining on the canal walls and in dentinal tubules. Photographs taken 10 μm below the surface at 20× with Zen 2012 (Zeiss) were analyzed using Metamorph software (Molecular Devices LLC, Sunnyvale, CA).

The amount of debris remaining in the canal space was calculated as follows: amount of debris in the canal space divided by the total canal space × 100 (%). The amount of residual sealer in the dentinal tubules was measured in 2 aspects: (1) the area of sealer penetration into the dentinal tubules (aP)/the area of the horizontal root section (aR) × 100 (%); (2) the longest penetration depth was also measured (mm) (Fig. 1*A–I*).

Statistical Analysis

Retreatment time in each group and sealer penetration depth were compared using the Student t test ($P < .05$). The sealer penetration area and remaining debris were compared between the AH Plus group and the BC sealer group using the Mann-Whitney U test ($P < .05$).

Results

There was no significant difference in canal orifice morphology between the 2 groups. The average retreatment times required in the AH Plus and BC groups were 323 and 337 seconds, respectively ($P > .05$) (Fig. 2). There was no significant difference in retreatment time between the 2 groups. Canal patency was achieved in all specimens.

A scanning electron microscopic image of a retreated canal (Fig. 3*A–F*) reveals that canal cleanliness was not obtained at an ideal level, and the canal wall showed an irregular state of debris remaining in both groups.

The amounts of debris on the root canal walls in the AH Plus and BC groups are shown in Figure 4*A* and *B*; there was no significant difference between sealer types at either level. The areas of sealer penetration (aP/aR %) in the AH Plus and BC groups are shown in Figure 4*C* and *D*. There was no significant difference between the groups in the dentin penetration area. Regarding the penetration depth of the sealer, the AH Plus group showed a slightly deeper percentage than the BC sealer at both 3 and 6 mm. The respective values in the AH Plus group and BC group were 1.16 ± 0.02 mm and 0.800 ± 0.099 mm in root dentin 3 mm from the apex ($P > .05$) and 1.14 ± 0.17 mm and 0.573 ± 0.099 mm in root dentin 6 mm from the apex ($P < .05$), with a statistically significant difference only observed at the 6-mm length (Fig. 4*E* and *F*).

Discussion

Under the conditions of the present study, there was no significant difference in retrievability between the AH Plus and BC sealer groups. The only statistically significant difference was in sealer penetration depth, which showed a significantly higher percentage in the AH Plus group. This may have been caused by the relatively higher fluidity of AH Plus (18).