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Micro CT pilot evaluation of removability of two endodontic sealers

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Abstract

Purpose: This study compared the removability of AH Plus and EndoSequence BC sealers using in vitro micro-computed tomography.

Methods: Ten single-canal, extracted human teeth were cleaned and shaped with ProTaper NEXT rotary files to size X5 (50/0.06) (Dentsply-Sirona). Canals were obturated with a single cone gutta-percha and either AH Plus (Dentsply-Sirona) (Group A) or EndoSequence BC (Brasseler) (Group B). ProTaper Universal Retreatment files (Dentsply-Sirona) were used to remove obturation materials after 90 days at 37°C/100% humidity. Each tooth was scanned using micro-computed tomography (SkyScan 1272; Bruker) at an isotropic resolution of 6 μm from which the percent of material removed was calculated. Two-sample t-tests and one-way ANOVA were used for analysis.

Results: The percent removal of materials in the coronal third was 92.9 ± 7.3% (Group A) and 93.2 ± 6.1% (Group B). Removal in the middle third was 94.9 ± 8.5% (Group A) and 96.5 ± 6.1% (Group B). Apical third removal was 76.2 ± 27.9% (Group A) and 70.1 ± 30.8% (Group B). No statistically significant differences were determined between the two sealers or among the sectional thirds within each group (P > 0.05).

Conclusion: AH Plus and EndoSequence BC sealers exhibit the same removability at all canal levels of 70% to 96%, with better removal coronally.

Keywords: endodontic retreatment, endodontic sealer, epoxy resin, tricalcium silicate, x-ray micro-computed tomography

Introduction

Endodontic treatment is considered a predictable procedure; however, a multifactorial failure rate of 14-16% has been reported [1]. Endodontic retreatment is often recommended after failure of the primary non-surgical root canal treatment (NSRCT). Caution is paramount in endodontic retreatment because re-accessing the root canal system places the tooth at greater risk for iatrogenic injury [2]. Retreatment is often successful but suffer from higher failure compared to initial NSRCTs [1]. Successful retreatment requires removing the previous obturation materials, such as gutta-percha (GP) and sealer, followed by disinfection of the root canal system [3].

Many methods of removing GP and sealer during endodontic retreatment have been evaluated [4]. The preferred retreatment technique is instrumentation with files combined with organic solvents to remove the GP and sealer used in the primary NSRCT [5]. The removability of a sealer is important for endodontic retreatment [6] because residual sealer makes up most of the material on canal walls after reinstrumentation. Current endodontic sealers, such as AH Plus (Dentsply-Sirona, Johnson City, TN, USA) and EndoSequence BC (Brasseler, Savannah, GA, USA), provide excellent three-dimensional sealing of canals and irregularities [7]; however, high bond strength to canal walls can lead to higher residue during retreatment [8]. AH Plus is an epoxy resin-based sealer regarded as a gold standard for sealers [9,10]. EndoSequence BC sealer, a calcium silicate cement-based sealer, has biocompatibility and high flowability [9,10]. However, limited information exists on the removability of EndoSequence BC or other tricalcium silicate-based sealers [11]. The present study evaluated the removability of AH Plus and EndoSequence BC sealers using micro-computed tomography (micro-CT).

Materials and Methods

Sample selection
Ten anterior, single-canal extracted human teeth, without evidence of fracture or cavitation, were selected. (University of New England, IRB#: 121515-014 not human subject research). The crowns of the teeth were removed with a diamond disk (Keystone industries, Gibbstown, NJ, USA), and the working length (WL) was determined by the use of size 10 K-file, 1 mm short of the radiograph apex on the WL radiograph.

Initial root canal treatment
The roots of the teeth were cleaned and shaped with ProTaper NEXT rotary files (PTN; Dentsply-Sirona) with a ProMark torque-limited electric motor (Dentsply-Sirona) to size X5 (50/0.06), following the manufacturer’s instructions, along with EndoGel root canal file lubricating gel (Jordco, Hillboro, OR, USA), which contains ethylenediaminetraacetic acid (EDTA). Irrigation was performed with 5 mL of 3% NaOCl between files. The canals were thoroughly dried with matching ProTaper NEXT absorbent points (Dentsply-Sirona). The prepared teeth were randomly divided into two groups (n = 5) and obturated using the single cone technique with size X5 GP points (50/0.06; Dentsply-Sirona) and one of the two endodontic sealers (Table 1) [10,12,13]. The GP was seared off at the cementoenamel junction. The obturated teeth were stored individually for 90 days at 37°C and 100% humidity incubator in 1.5-mL polyethylene tubes (VWR, Radnor, PA, USA).

Removal of obturated materials
Obturated materials were removed from root canals using ProTaper Universal Retreatment rotary files (PTR; Dentsply-Sirona) and the ProMark electric motor. The PTR system includes three files with various tapers and a cutting tip to facilitate penetration into obturation material. D2 and D3 have non-cutting tips to remove the obturating material from the middle and apical thirds, respectively [14]. No organic solvent was used to dissolve the GP. Removal was judged complete when the working length was reached, and no filling material was seen when the D3 file was removed under magnification. A single operator executed all instrumentation to eliminate intra-operator variability.

Scanning
Each tooth was scanned before (at 90 days after obturation) and after the removal of obturated materials using micro-computed tomography (micro-CT; SkyScan 1272; Bruker, Billerica, MA, USA) at 6 μm voxel size, 90 kVp, 110 μA, with 0.5 mm aluminum and 0.038 mm copper filters. All datasets were exported in the Digital Imaging and Communications in Medicine (DICOM) file format. The GP and sealer volume were measured using image analyzer software (CTAn v.1.18.40; Bruker). Each specimen was divided into coronal, middle, and apical thirds, measured from the
cementoenamel junction to the most apical part of the GP cone. Material volumes were calculated for each sectional third, creating three material volumes per tooth.

Statistical analysis

Shapiro-Wilk tests were conducted to investigate the normality of the data. Shapiro-Wilk tests showed the normality of the data ($P > 0.05$). Levene tests were done to examine the equality of variances among study groups. Levene tests showed that the variances were not significantly different among study groups ($P > 0.05$). Two-sample t-tests and ANOVA tests were used based on the normality of the data and equality of variances among study groups.

Two-sample t-tests were performed to determine if significant differences were present in GP length and total canal volume between AH Plus and EndoSequence BC sealers and the apical, middle, and apical levels after removal. ANOVA tests were performed to identify pairs of groups with significant differences. Statistical significance was defined using $\alpha = 0.05$.

Results

Tables 2 and 3 show GP length (about 12 mm), the calculated total canal volumes (7.4 and 10.5 mm$^3$), and each sectional third for both groups (1.2 to 5.9 mm$^3$). The data is presented as the average and the standard deviations (SD). No significant differences were found in total GP length ($P = 0.35$) or total canal volume ($P = 0.15$) between the sealers. Percent removal was calculated using the following equation:

$$\text{Percent removal} = \left(1 - \frac{\text{Volume of material after removal}}{\text{Volume of material before removal}}\right) \times 100\%$$

The average percent removal of GP and sealer is shown with their respective standard deviations (Table 4).

Table 1: Endodontic sealers used in this study

| Type                  | Product name (manufacturer, country) | Composition                                                                 | Lot number | Working time | Setting time |
|-----------------------|--------------------------------------|-----------------------------------------------------------------------------|------------|--------------|--------------|
| Epoxy resin           | AH Plus (Dentsply-Sirona, Johnson City, TN, USA) | paste A bisphenol A epoxy resin, zirconium oxide, bisphenol F epoxy resin, calcium tungstate, iron oxide, silica | 00000119047 | 4 h          | 8.3 h        |
|                       |                                       | paste B N,N-dibenzyl-5-oxanonadiamin-1,9, amantiamine, tricyclodecane-diamine, calcium tungstate, zirconium oxide |            |              |              |
| Tricalcium silicate cement | EndoSequence BC (Brasseler, Savannah, GA, USA) | single paste zirconium oxide, calcium silicates, calcium phosphate, calcium hydroxide, filler, thickening agents | #(10)16002SP | >24 h        | 2.7 h        |

Table 2: Average gutta-percha (GP) length (mm) with standard deviations (SD)

| Group: sealer | GP length (mm) | SD  | Coefficient of variation |
|---------------|----------------|-----|--------------------------|
| A: AH Plus    | 11.3           | 1.4 | 0.1                      |
| B: EndoSequence BC | 12.1         | 1.1 | 0.1                      |

Table 3: Average total canal volume (mm$^3$) by sealer group with standard deviations (SD)

| Group: sealer | Sectional third | Total canal volume (mm$^3$) | SD  | Coefficient of variation |
|---------------|-----------------|----------------------------|-----|--------------------------|
| A: AH Plus    | coronal         | 5.9                        | 2.6 | 0.4                      |
|               | middle          | 3.1                        | 1.1 | 0.3                      |
|               | apical          | 1.5                        | 0.4 | 0.3                      |
|               | total           | 10.5                       | 2.8 | 0.3                      |
| B: EndoSequence BC | coronal        | 3.7                        | 0.5 | 0.1                      |
|               | middle          | 2.6                        | 0.5 | 0.2                      |
|               | apical          | 1.2                        | 0.4 | 0.3                      |
|               | total           | 7.4                        | 0.8 | 0.1                      |

Table 4: Average percent removal of gutta-percha (GP) and sealer with standard deviations (SD)

| Group: sealer | Sectional third | GP + sealer percent (%) | SD  | Coefficient of variation |
|---------------|-----------------|-------------------------|-----|--------------------------|
| A: AH Plus    | coronal         | 92.9                    | 7.3 | 0.1                      |
|               | middle          | 94.9                    | 8.5 | 0.1                      |
|               | apical          | 76.2                    | 27.9| 0.4                      |
| B: EndoSequence BC | coronal        | 93.2                    | 6.1 | 0.1                      |
|               | middle          | 96.5                    | 6.1 | 0.1                      |
|               | apical          | 70.1                    | 30.8| 0.4                      |

100% is complete removal of the obturation materials. Coefficient of variation is computed by dividing SD by GP + sealer percent (%).
This study found GP and sealer could not be removed completely. Removal evaluations of AH Plus versus EndoSequence BC (or other tricalcium silicate sealers) have proven equivocal across the research. In some studies, more EndoSequence BC sealer remained after removal of obturated materials than AH Plus, especially in the coronal third [11,28,30]. These studies [11,28,30] attribute this difference to the fact that AH Plus and EndoSequence BC sealers, and suitable for micro-CT [17,18]. The favorable filling quality of EndoSequence BC and other tricalcium silicate sealers achieved a 90.9% success rate [18]. Huang et al. [17] reported that AH Plus had more voids at all root levels when compared to EndoSequence BC sealer by the single cone technique.

Removal of obturated materials was done after 90-day incubation to simulate a clinical timescale, longer than other studies (one to six weeks) [16,19-23]. NiTi rotary retreatment files were used to achieve conservative and uniform instrumentation with a short working time, like other retreatment studies [15,19,21,22,24]. The PTR system was chosen to be consistent with other studies that used it for standardized retreatment procedures [14,15,20,22,23,25-28]. Monguilhott et al. found that PTR files removed more filling material in the apical region than in the coronal and apical regions [23]. Huang et al. described how PTR files (D1, D2, and D3) extruded approximately 0.4 mg of debris apically when used without solvent [25]. In their study, Huang et al. employ PTR files (D1, D2, and D3) to ensure uniform instrumentation among the teeth [25]. The residual filling material may be attributed to ovate canal shape, which PTR files cannot easily access [19]. Additional apical enlargement could decrease the apical sealer residue by either hand or rotary files [29]. Ultrasonic activation of irrigants with an irrisonic tip is also a viable method to improve material removal in the apical and middle thirds, where branching and finer canals are present [16].

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**Conflict of interest**
The authors declare no conflict of interest.

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