Removal of Endosequence BC/CPoint endodontic fillings in curved root canals using rotary or reciprocating instruments

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ABSTRACT

Objective: This study used micro-CT to evaluate the amount of remaining filling material in curved root canals obturated with Endosequence BC Sealer/Cpoint or AH/gutta-percha after a rotary or reciprocating retreatment. **Methods:** Sixty mesiobuccal canals of maxillary molars were instrumented up to MTwo #35.04. Samples were randomly assigned to four groups (n=15): canals from G1 and G2 were filled with AH/gutta-percha, and canals from G3 and G4 were filled with BC/Cpoint. Filling material was removed using rotary or reciprocating instruments: G1 and G3: R25 Reciproc + re-shaping with R40; and G2 and G4: ProTaper Universal Retreatment system + re-shaping with MTwo 40.06. Micro-CT was used to measure the remaining amount of filling material (mm^3), for the whole canal, and for each third, in two moments: 1) after filling removal and 2) after canal re-shaping. **Results:** After filling removal, BC/CPoint remained more into the canal than AH/Gutta-percha when the whole canal (29.92% x 19.25%, $p = 0.0290$) and the apical third were analyzed. After re-shaping, BC/CPoint remained more than AH/Gutta-percha only in the apical third. Rotary or reciprocating retreatment protocols removed filling material without difference for AH/gutta-percha (G1 and G2: $p > 0.05$) and BC/CPoint (G3 and G4: $p > 0.05$). **Conclusion:** BC/Cpoint is more difficult to be removed from curved root canals than AH/gutta-percha. Reciprocating and rotary instruments have similar ability to remove filling material.

Keywords: Root Canal Therapy. Root Canal Filling Materials. X-Ray Microtomography. Dental Instruments.

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Introduction

Clinicians face many challenges during root canal treatment. These difficulties may be related to the properties of the filling material resulting in a poor endodontic therapy. An expected property for an ideal endodontic filling material is the ability to be easily removed from the root canal if necessary.

A contemporary endodontic sealer, the Endosequence BC (BC; Brasseler, Savannah, GA, USA), was developed aiming to achieve an optimal interface, without gaps, between the canal walls and the filling material. Although the manufacturer states that the sealer has excellent physical properties. BC raises concerns amongst dentists, because it might become too hard upon setting, making the root canal retreatment a challenge. However, few studies have investigated the BC retreatability. One study that assessed radiographs of filled teeth, found that the amount of remaining BC/gutta-percha after retreatment with hand files and rotary instruments was similar to other types of sealers, including AH Plus (AH; Dentsply Maillefer Ballaigues Switzerland).[1] In contrast, a more recent study, using micro CT scanning, the state-of-the-art method to investigate remaining filling material,[2-4] has emphasized the difficulties to remove BC/gutta-percha from the root canals.[5]

CPoint (EndoTechnologies, Shrewsbury, MA, USA) is an alternative to gutta-percha to be used in combination with BC sealer. CPoint is a single cone consisting of a radiopaque core and a hydrophilic polymer coating. When CPoint is inserted into the root canal filled with BC, it expands and pushes the sealer radially, being able to fill the irregular canal spaces.[6,7]

To the best of our knowledge, there are no studies addressed to the possibility of retreating root canals obturated with BC combined with CPoint. The nature of both materials, sealer and core, might impair or even prevent an appropriate therapy.

In an attempt to completely remove the previous root canal obturation during endodontic retreatment several investigations have examined the ability of different endodontic instruments and different retreatment protocols to achieve this objective. Superior removal of remaining filling material has been associated with larger preparation sizes, hybrid instrumentation techniques[4] and canal re-shaping.[8]

Considering the clinical relevance of achieving optimal filling removal during root canal reintervention and the necessity to better know about the retreatability of this new endodontic filling system, the aim of this in vitro study was: to evaluate, using micro-CT, the amount of remaining filling material in curved mesiobuccal canals of maxillary molars obturated with BC/Cpoint or AH/gutta-percha after using rotary or reciprocating instruments.

The null hypotheses tested in this study were: 1) there would be no difference between BC/CPoint and AH/gutta-percha in relation to the amount of remaining filling material and 2) there would be no difference between rotary and reciprocating instruments regarding the ability to remove filling material.

Materials and Methods

Sample Preparation

This study was approved by the Lutheran University of Brazil research ethics committee where the experiment was conducted (65555216.1.0000.5349).

Sixty human extracted maxillary first permanent molars extracted for different clinical reasons were used. Sample calculation was performed using the Statistical Package for the Social Sciences version 13.0 (SPSS Inc, Chicago, IL) considering the power of the test = 0.95 and $\alpha = 0.05$. Constant parameter to estimate the effectiveness of filling material removal was based on a previous study.[9] As a result the number of samples needed to detect statistical difference were 15.

Canal curvature was determined by measuring the angle and radius of curvature and the length of the curved part of the canal according Schafer et al.[10]. Mesiobuccal canals with curvature ranging between 15° to 30° were included.[9] Canals that had showed calcification, intra radicular post, fractures, resorption or teeth that suffered previous endodontic intervention were excluded.

A specialist in endodontics and trained in all of the techniques used in this experiment, performed all procedures. The working length was determined at 1.0 mm short of the apical foramen. The apical region of the roots was covered with utility wax to be included in acrylic resin blocks. Irrigation was performed with 2.5% sodium hypochlorite (20mL for each specimen) and finalized with 1mL 17% EDTA for 1 min

and distilled water (5mL). The penetration depth of the NaviTip needle (0.30 mm Ultradent, São Paulo, Brazil) was 3mm shorter than the working length. Size #10 and #15 K-files were used to maintain patency beyond the apical foramen.

Samples were randomly allocated to different groups (n=15) according to the filling material used for obturation: Groups 1 and 2, AH/gutta-percha; and Groups 3 and 4, BC/CPoint.

Filling procedures

Canals from G1 and G2 were filled with AH/gutta-percha using the single-cone technique (35/.04 VDW, Munich, Germany). The selected gutta-percha cone was covered with sealer and slowly inserted into the root canal up to the working length. A McSppaden compactor (Dentsply Maillefer Ballaigues Switzerland) was used for thermo filling and the gutta-percha was vertically compacted with a size-fitting plugger at the root canal orifice.

Canals from G3 and G4 were filled with BC/Cpoint. After irrigation, the canals were slightly dried. The verifier cone provided by the manufacturer was positioned and radiographed. Then, the correspondent Cpoint cone was cut at 1 mm under the root canal orifice. The sealer was inserted into the canal with the manufacturer syringe and the Cpoint was covered with sealer and positioned.

The entrance orifices of the canals were restored with glass-ionomer and the specimens were stored in an incubator with 95% humidity and 37°C for 1 month.

Filling material removal

In G1 and G3 groups, the filling material was removed with Reciproc (Rec) (VDW, Munich, Germany). R25 instrument was driven with a VDW Silver motor (VDW, Munich, Germany) using an in-and out motion with amplitude of 3 mm and a brushing motion against the lateral walls of the canal. After performing 3 strokes, the instrument was removed from the canal and cleaned with sterile gauze, and the canal was flushed with 2.5% NaOCl. This procedure was repeated until the instrument reached the working length. The filling material removal was considered completed when the operator, using magnification lens (3.0 x), noticed the absence of material attached to the instrument and the sensation of smooth canal walls. This procedure was carefully undertaken and it took around 5 minutes for each tooth. Patency was verified with a #10 file that was extended 1 mm past the foramen. Subsequently, re-shaping was performed with R40 instrument. Re-shaping was defined as an increase in canal apical diameter after the original master file.

In G2 and G4 groups, the filling material was removed with ProTaper Universal Retreatment (PTret) (Dentsply Maillefer Ballaigues Switzerland) driven with X-smart motor (Dentsply Ballaigues Switzerland) at a speed of 500-700 rpm and torque of 2 N/cm. D1, D2 and D3 instruments were used in a crown-down technique to remove material from the coronal, middle and apical third respectively. Irrigation, confirmation about the absence of filling material, and patency were performed identically for G1 and G3. Subsequently, re-shaping was performed with MTwo 40.06.

All samples obturated with BC/CPoint had some drops of warm water (as recommended by the manufacturer) applied in between the sodium hypochlorite irrigation.

3D Micro-CT imaging: measuring remaining filling material

Micro-CT scans were obtained (Bruker-microCT, Kontich, Belgium) at the following parameters: scanning voltage 90 kV, current: 278 mμ, 0.5° rotation step and 360° acquisition, an isotropic resolution of 17.42 μm at three moments: i) after root canal obturation, ii) after removal of the filling material and iii) after re-shaping. NRecon v.1.6.9 software (Bruker-microCT) was used for image reconstruction by using a fine-tuning for noise reduction: gaussian filter (smoothing = 3), beam hardening correction of 19%, post-alignment of 0.5 to compensate possible misalignment during acquisition, and ring artifact correction of 10. The reconstructed images of the canal after filling removal and after re-shaping were superimposed to the pre-operative images (obturation) by using the 3-dimensional (3D) registration function of DataViewer v.1.5.1 software (Bruker microCT). Then the images were analyzed with the CTAn v.1.15 software (Bruker microCT) to calculate the remaining volume of filling material (mm3) (for

each third and for the whole canal) and to obtain 3D models. CTVol v.2.3 software (Bruker microCT) was used for 3D model visualization.

Data Analysis

The values, in mm^3, of remaining filling material were compared among the groups in two moments during the canal re-intervention (after filling removal and after re-shaping), taking into consideration the thirds of the canal and the instrument technique used.

A single examiner assessed the images twice with 10 days interval between the two assessments. Intraclass correlation coefficients (ICC) were used to evaluate intra examiner reproducibility for all measures. Multiple comparisons were analyzed using ANOVA and Bonferroni`s test. Statistical analysis was performed using the Statistical Package for the Social Sciences version 13.0 (SPSS Inc, Chicago, IL). Significance was set at $P \leq .05$.

Results

ICC values for intra-examiner reproducibility for all measurements were 0.7 ($p > 0.05$). Table 1 shows that none of the canal retreatment protocols was able to completely remove the filling material from any of the evaluated root canal thirds. The amount of remaining filling material was reduced in all groups after re-shaping. After filling removal, BC/CPoint remained more into the canal than AH/Gutta-percha when the whole canal (29.92% x 19.25%, $P = 0.0290$) and the apical third (65.16% x 25.24%, $P = 0.0001$) were analyzed. After re-shaping, BC/CPoint remained more than AH/Gutta-percha only in the apical third. Figure 1 exemplifies images of each group during the three time-point evaluations: 1) after root canal filling, 2) after filling material removal, and 3) after re-shaping.

Rotary or reciprocating canal retreatment protocols had similar ability to remove filling material without difference for AH/gutta-percha (G1 and G2: $p > 0.05$) and BC/CPoint (G3 and G4: $p > 0.05$).

Table 1. Mean and standard deviation of remaining filling material (mm^3) in canals obturated with AH/gutta-percha and BC/CPoint after using rotary and reciprocating instruments, in two moments during retreatment: after filling removal and after re-shaping.

Remaining of filling material (mm3)	Root Canal Third	AH Plus + Gutta-percha		Endosequence BC + CPoint	
		Reciprocating G1	Rotary G2	Reciprocating G	Rotary G4
After removal	Cervical	18.54 ± 16.59	14.59 ± 23.78	25.39 ± 20.93	18.48 ± 12.90
	Middle	23.03 ± 23.72	17.04 ± 29.07	32.03 ± 24.55	26.39 ± 16.56
	Apical	31.69 ± 30.62 a	18.79 ± 28.36 a	64.25 ± 27.93 b	66.08 ± 25.85 b
	Total	21.81 ± 16.52a	16.70 ± 23.54 a	32.61 ± 19.13 b	27.24 ± 12.86 b
After re-shaping	Cervical	14.29 ± 17.56	13.22 ± 23.55	15.29 ± 12.68	13.79 ± 13.33
	Middle	20.35 ± 23.30	15.10 ± 27.28	16.85 ± 18.21	19.45 ± 15.80
	Apical	17.61 ± 20.97 a	14.66 ± 25.86 a	34.49 ± 32.71 b	49.61 ± 29.85 b
	Total	16.49 ± 15.74	14.51 ± 25.15	18.01 ± 14.97	20.59 ± 13.09

Different letters in the same line indicate statistical difference between Groups. ANOVA followed by Bonferroni's test ($p < 0.05$).

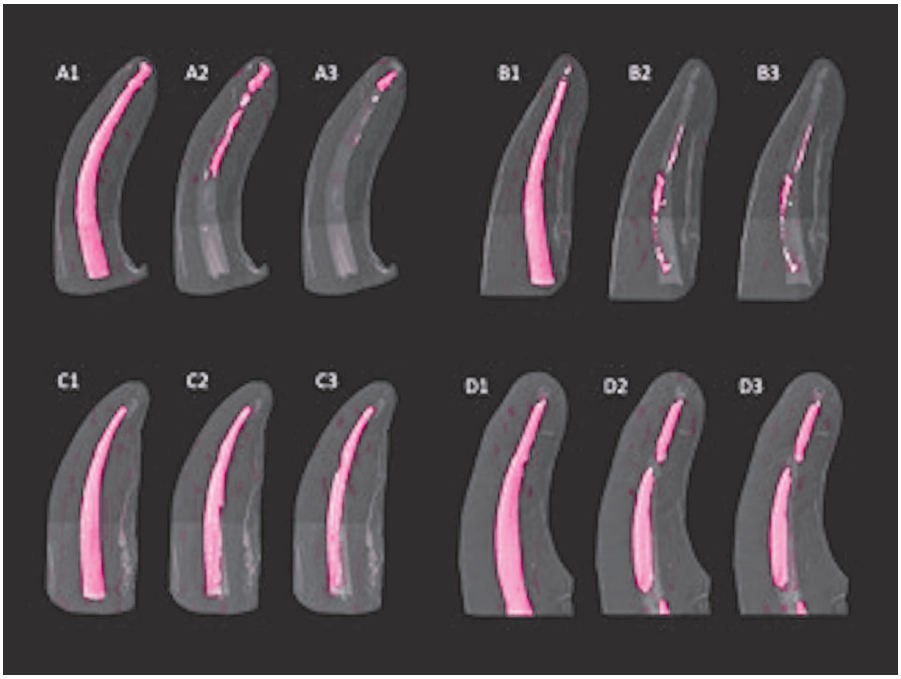

Figure 1. Three-dimensional reconstructions of root canal filling (1), and remaining filling material after filling removal (2) and after re-shaping (3). G1: AH plus/Gutta-percha + reciprocating (A); G2: AH plus/Gutta-percha + rotary (B); G3: BC sealer/CPoint + reciprocating (C); and G4: BC sealer/CPoint + rotary (D).

Discussion

This study is the first to show the challenges to remove BC/CPoint from curved root canals. Previous studies had investigated the retreatability of BC when combined with gutta-percha[5,11,12] but not when combined with CPoint.

After filling material removal, samples obturated with BC/CPoint had more amount of remaining filling material compared to the samples obturated with AH/gutta-percha (whole canal and apical third). After canal re-shaping the samples obturated with BC/CPoint had more amount of remaining filling material, only in the apical third. Therefore, the first null hypothesis was rejected. Rotary and reciprocating retreatment protocols had similar ability to remove filling materials, thus, the second null hypothesis was accepted.

Some characteristics can support the idea that BC/CPoint filling system is difficult to be removed: i) the hardness of BC upon setting;[11,12] ii) the BC hydrophilic nature, when compared to the hydrophobic nature of other sealers (as AH for instance), which may result in more intimate contact with canal walls,[13,14] because BC is able to form a chemical bond with the inorganic phase of dentin;[15,16] iii) the CPoint composition (nylon core + polymeric hydrogel coating) and its mechanism of action (expanding action), making it hard and well adapted to the canal space, and iv) the higher BC/CPoint bond strength to dentin when compared to AH/gutta-percha.[7]

The operator needed to spend more effort and energy to remove BC/CPoint. Warmed water was necessary to soften the hydrophilic polymer, and the instruments tip had to be directed towards the interface BC/canal walls (and not towards the CPoint) to prevent the instrument from sliding. This operator`s feedback is important to guide our decision-making between canal retreatment and surgical intervention, especially when facing a radiographically well obturated root canal with BC/CPoint.

In our investigation, rotary and reciprocating instruments had similar ability to remove filling material. Although previous studies had showed that larger sizes of reciprocating instruments were more effective than rotary retreatment instruments,[3,17] a novel systematic review concluded that rotary and reciprocating instruments exhibit similar abilities to remove filling material.[4] It is worth highlighting that the operator who performed the experiment noticed that reciprocating (R25) instrumentation appeared to be safer

in comparison to rotary (PTret), which seemed to be more fragile. This impression was felt for both type of filling materials, BC/CPoint and AH/gutta-percha. Rec instruments are not fabricated specifically for canal retreatment; however, in this study, they presented similar performance to PTret, which are instruments specifically dedicated for retreatment.

As well documented,[4,18-20] our study also showed that none of the reintervention protocols was able to completely remove filling material and the majority of the material remained in the apical third.[1] The percentage of remaining filling material in the whole canal was 29.92% for BC/CPoint and 19.25% for AH/gutta-percha. The literature has reported that values of residual filling material ranged from 43.9% to 0.02%, and the value of 0.5% as a cutoff point to reflect "effective canal cleaning".[4] Using these values as parameters for our study, the percentages of remaining material for both filling systems would be within the limits reported previously, but far from being considered optimal values (especially for BC/CPoint). Canal disinfection depends on various aspects, including canal morphology and biofilm location,[4] and, perhaps, total removal of the endodontic filling would not be an essential factor in retreatment because not all filling materials would have negative effects if remained into the canal.[21]

Less filling material was found in all groups after re-shaping with instruments R40 (in Groups 1 and 3) or MTwo 40/.06 (in Groups 2 and 4). In addition, after re-shaping, samples obturated with BC/CPoint had more amount of remaining filling material only in the apical third, when compared to the samples obturated with AH/Gutta-percha. This finding shows the positive impact of re-shaping to remove BC/CPoint, and it emphasizes the challenges imposed by the anatomical complexities of curved canals in the apical third. Canal re-shaping has already been performed in other studies.[1,8,22] It is known that the additional apical enlargement should be responsible for better cleaning,[23] but there is the possibility to promote canal anatomical aberrations.[24-26]

Conclusion

In light of the limitations of this in vitro study, our findings allow to conclude that BC/Cpoint is more difficult to be removed from root canals than AH/gutta-percha. However, we hypothesize for a further study that the difficulties to remove BC/CPoint might mean that this filling system could be very effective to fill the curved root canals in their three dimensions. Reciprocating and rotary retreatment protocols had the same ability to remove filling material.

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