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Clinical Microscopic Analysis of ProTaper Retreatment System Efficacy Considering Root Canal Thirds Using Three Endodontic Sealers

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ABSTRACT To evaluate the efficacy of ProTaper Universal rotary retreatment system and the influence of sealer type on the presence of filling debris in the reinstrumented canals viewed in an operative clinical microscope. Forty-five palatal root canals of first molars were filled with gutta-percha and one of the following sealers: G1, EndoFill; G2, AH Plus; G3, Sealapex. The canals were then reinstrumented with ProTaper Universal rotary system. Roots were longitudinally sectioned and examined under an operative clinical microscope (10×), and the amount of filling debris on canal walls was analyzed using the AutoCAD 2004 software. A single operator used a specific software tool to outline the canal area and the filling debris area in each third (cervical, middle, and apical), as well as the total canal area. Data were analyzed by Kruskal-Wallis test and Tukey test at $P < 0.05$. Sealapex demonstrated significant differences in the average of filling debris area/canal among the 3 thirds. This group revealed that apical third showed more debris than the both cervical and middle third ($P < 0.0001$). Endofill presented significantly more filling debris than Sealapex in the cervical third ($P < 0.05$). In the middle ($P = 0.12$) and apical third ($P = 0.10$), there were no differences amongst groups. Debris was left in all canal thirds, regardless of the retreatment technique. The greatest differences between techniques and sealers were found in the cervical third. *Microsc. Res. Tech.* 75:1233–1236, 2012. © 2012 Wiley Periodicals, Inc.

INTRODUCTION

Nonsurgical endodontic retreatment is indicated when infection persists or recurs after treatment, especially if the existing root canal therapy is technically deficient (Schirrmeyer et al., 2006a,b,c). Thus, the main objective of nonsurgical retreatment is to remove all material filling from the root canal and to regain access to the apical foramen. The difficulty in gutta-percha removal is directly related to canal preparation and filling techniques, the type of sealer as well as the time elapsed since the original treatment. The majority of laboratory studies examined teeth with root fillings performed a short time before retreatment, without investigating all representative types of sealers (Barrieshi-Nusair, 2002; Imura et al., 2000). Debris is left on canal walls after root canal retreatment, regardless of the type of instrumentation or filling material, and even solvents do not change this trend (Barrieshi-Nusair, 2002; Gergi and Sabbagh, 2007; Gu et al., 2008; Huang et al., 2007; Hülsmann and Bluhm, 2004; Imura et al., 2000; Kosti et al., 2006; Maciel and Scelza,

2006; Masiero and Barletta, 2005; Saad et al., 2007; Sae-Lim et al., 2000; Scelza et al., 2008; Schirrmeyer et al., 2006a,b,c; Só et al., 2008; Somma et al., 2008).

The techniques used to remove gutta-percha are varied and include the use of hand or rotary instruments with or without solvents. Nickel-titanium (NiTi) rotary instruments have also been used for the removal of filling materials from root canal walls, and various studies have reported their efficacy, cleaning ability, and safety (Gergi and Sabbagh, 2007; Huang et al., 2007; Saad et al., 2007; Schirrmeyer et al., 2006a). ProTaper Universal rotary system improved the previous ProTaper series by adding retreatment instruments designed specifically to remove obturation material from root canals. However, few data are yet available about the behavior of ProTaper Universal during

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endodontic retreatment procedures (Giuliani et al., 2008; Gu et al., 2008).

The influence of type of sealer in this novel retreatment system technique needs further investigation. This *in vitro* study aimed to analyze the ProTaper Universal (Dentsply/Maillefer, Ballaigues, Switzerland) rotary retreatment system for removal of filling material during root canal retreatment with regards to the influence of the type of sealer on the presence of filling debris in the re-instrumented canals. The tested hypotheses were: (1) sealer type influences the amount of filling material that remains in dentin walls; and (2) it is harder to remove filling debris from the apical third.

MATERIAL AND METHODS

This study used a methodology similar to a previous study (Maciel and Scelza, 2006) except for the sealer type and the sole use of rotary instrumentation during retreatment. Forty-five maxillary first molars were radiographed and selected if they had a palatal root with a single straight canal (or curvature < 5 degrees) and fully formed apex. The apical 16 mm of the palatal roots was sectioned as to standardize canal length in all teeth.

Initial Endodontic Treatment

The canals were prepared according to a crown-down technique with Flexofile hand files (21 mm, 1st/2nd series; Dentsply/Maillefer, Ballaigues, Switzerland). The cervical and middle thirds were preflared with Gates-Glidden drills sizes 2 and 3 (Dentsply/Maillefer). Each canal was negotiated with a size 15 file until its tip was visible at the apical foramen, and the working length (WL) was established 1 mm short of canal length (15 mm). The apical stop was prepared with a size 30 file. Canals were irrigated with 1 mL 1% NaOCl at each change of file. When instrumentation was completed, the canals were filled with 17% EDTA during a period of 3 min, flushed with 1% NaOCl, dried with absorbent paper points, and randomly divided in three groups (15 specimens each) according to the endodontic sealer: G1, a zinc oxide—eugenol (ZOE)—based sealer (Endofill; Dentsply Ind e Com Ltda, Petrópolis, RJ, Brazil); G2, an epoxy resin-based sealer (AH Plus; Dentsply De Trey GmbH, Konstanz, Germany); G3, a calcium hydroxide-based sealer (Sealapex, Kerr Corporation, Orange, California, USA). Canals were filled using lateral compaction of thermoplasticized gutta-percha. Sealers were taken to the canals with the master gutta-percha cone, which was coated and inserted in a single movement. The quality and apical extent of root fillings were confirmed radiographically. The specimens used in this experiment had well-compacted fillings extending to 1 mm short of the apex. The access cavities were sealed (Coltosol; Coltene-Whaledent, Cuyahoga Falls, OH), and the roots were stored in artificial saliva (Farmácia Marcela, Porto Alegre, Brazil) at 37°C for 3 months.

Endodontic Retreatment

All the roots had the canals emptied with the ProTaper Universal NiTi rotary retreatment files and re-instrumented with ProTaper Universal NiTi rotary shaping and finishing instruments, following manufac-

TABLE 1. Filling debris area/canal area ratios (%) in the cervical, middle, apical thirds for the different groups

Groups	Cervical	Middle	Apical	Overall
Endofill	17.1 ^{Aa} (20.8)	15.9 ^{Aa} (23.6)	16.1 ^{Aa} (16.2)	17.8 ^a (14.5)
AH Plus	13.6 ^{Aa} (13.7)	17.0 ^{Aa} (19.2)	24.1 ^{Aa} (28.3)	15.8 ^a (16.7)
Sealapex	2.0 ^{Ab} (3.8)	11.9 ^{Ba} (21.8)	26.2 ^{Ca} (22.8)	16.1 ^a (15.5)

Values expressed as means (standard deviations). Means followed by different uppercase letters in rows and different lowercase letters in columns differ significantly (Kruskal–Wallis and *post hoc* Tukey test, $P < 0.05$).

turer's instructions. Root fillings were removed by using the D1, D2, and D3 retreatment instruments, which have a convex cross section with taper/tip diameter of 0.09/0.30, 0.08/0.25, and 0.07/0.20 mm, respectively. D1, D2, and D3 files were activated by an electric engine (Endo-Pró, Driller, São Paulo, SP, Brazil; 3 N/cm torque, 500 rpm speed) and used with a brushing action in a crown-down manner at the cervical, middle, and apical canal thirds, respectively, until reaching the WL. When 1 mm of filling material was left apically, the final canal portion was negotiated by using sizes 15 and 20 files with 1% NaOCl. Canal refinement was accomplished with the shaping (S1 and SX in the cervical third and S2 in the middle third) and finishing instruments (F1, F2, and F3 up to WL) at 2 N/cm torque and 250 rpm speed. No solvent was applied. Canals were irrigated with 1% NaOCl between files, replenished with 17% ethylenediaminetetraacetic acid after re-instrumentation, and flushed again with 1% NaOCl.

Analysis of Filling Debris

The roots were grooved longitudinally in a buccolingual direction with a diamond disk and split into halves with a chisel. The root half with greater amount of filling debris on visual inspection was examined with an operative clinical microscope at 10× magnification (DF Vasconcellos, São Paulo, SP, Brazil). Images were captured with a digital camera (Nikon-Coolpix, Tokyo, Japan) coupled to the microscope (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License) and analyzed with AutoCAD 2004 software (Mechanical Desktop Power Pack; Microsoft, Redmond, WA). A single operator used a specific software tool to outline the canal area and the filling debris area in each third (cervical, middle, and apical), as well as the total canal area. The filling debris area/canal area ratios were considered for statistical analysis and expressed as percentage of filling material left after re-instrumentation. Data were analyzed by Kruskal–Wallis test and Tukey test at $P < 0.05$. First, statistics compared the canal thirds within each group; next, the groups were compared in each canal third; finally, intergroup comparison considered the total canal area to calculate the filling debris area/canal area ratios.

RESULTS

Table 1 compares the groups regarding the filling debris area/canal area ratios in each canal third. The first hypothesis was confirmed. Endofill presented significantly more filling debris than Sealapex in the cervical third ($P < 0.05$). In the middle ($P = 0.12$) and apical third ($P = 0.10$), there were not statistical differences among groups. Kruskal–Wallis test showed that Sealapex demonstrated statistical significant differences in the average of filling debris area/canal among the three

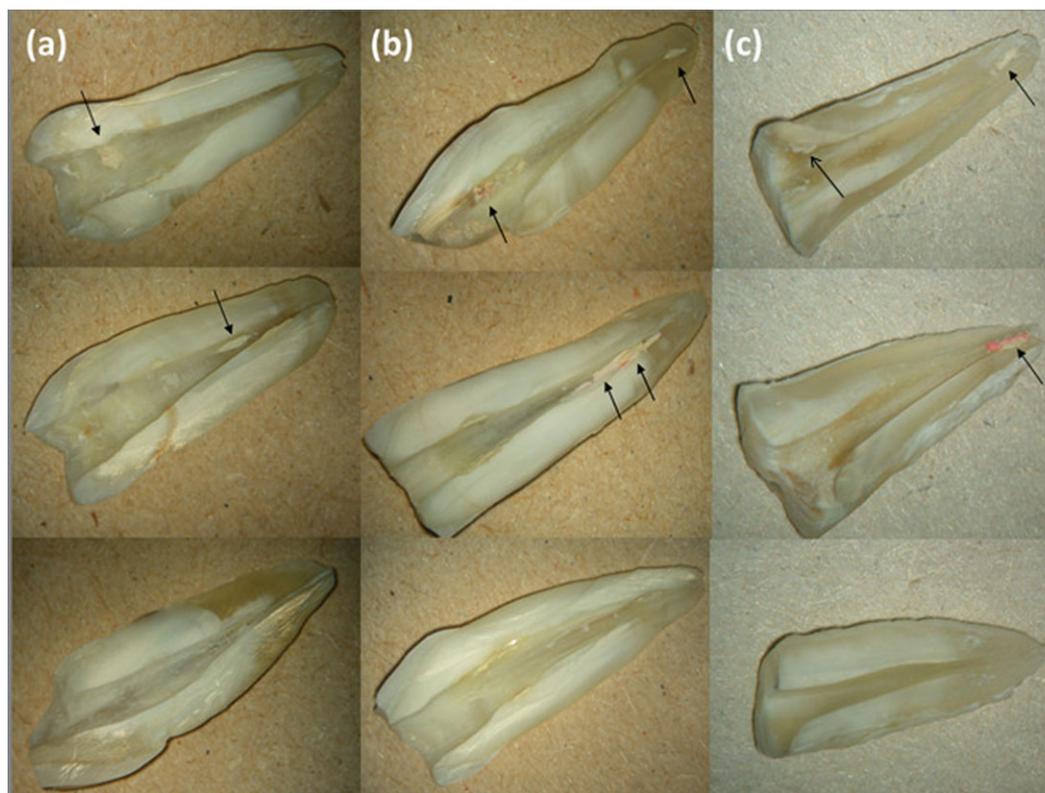


Fig. 1. Clinical microscopic images, $\times 10$ magnification. **a:** Endofill: debris in the cervical and middle third (arrows). **b:** AH Plus: debris in the apical, middle, and cervical third (arrows); Sealapex: presence of filling debris in the cervical and middle thirds (arrows). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

thirds ($P < 0.0001$). Tukey test revealed that the apical third showed more debris than the both cervical and middle third ($P < 0.05$). Thus, the second hypothesis was also confirmed. This study did not detect differences between the groups considering the total canal area ($P > 0.05$). Figure 1 presents the clinical microscopic images of the debris for the three endodontic sealers.

DISCUSSION

Removal of filling material is an important factor in root canal retreatment because it allows chemomechanical reinstrumentation and re-disinfection of the root canal system. It provides better access to the necrotic tissue remnants and microorganisms. However, previous studies have found that completely clean canal walls were not produced with any of the techniques investigated (Celik Ünal et al., 2009; Giuliani et al., 2008; Gu et al., 2008; Hülsmann and Bluhm, 2004; Kopper et al., 2006; Maciel and Scelza, 2006; Sae-Lim et al., 2000; Schirrmeister et al., 2006a,b,c). Giuliani et al. (2008) found ProTaper Universal retreatment system to perform better than hand K-File or Profile rotary instrumentation, but filling debris remain in all samples. Likewise, in this study, filling debris was found in all cleaved canals after endodontic retreatment with ProTaper Universal retreatment system. This differs from Takahashi et al. (2009) that found that this system without solvent (chloroform) was the one to better remove filling material. They

used one sealer type, Endofill. This sealer, according to a previous study (Kopper et al., 2006), allows leakage to a greater extent than adhesive sealers, which possibly makes it easier to be removed.

This study tested the hypothesis that sealer type could influence the amount of filling material that remains in dentin walls following retreatment when ProTaper Universal retreatment system is used. There was an interesting correlation for the cervical third, when Endofill and Sealapex are compared. Although significant difference was found, its clinical relevance is questionable. The cervical third is the one that can easily be cleaned when some complementary procedures are used.

The apical third was again the one to accumulate most debris following endodontic retreatment. This tendency occurs regardless of the sealer type. The presence of apical curvatures, deltas, ramifications, and the lack of control with the currently available instruments are amongst the possible causes for this occurrence. The number of uses of an instrument may add to the current worries during root canal preparation procedures (Troian et al., 2006). The ideal instrumentation during re-treatment procedures is something yet to be improved, maybe not with the NiTi rotary paradigm.

However, when the apical third was compared with the middle and coronal thirds (within each group), it was possible to find statistically significant differences. The sealers present different chemical components and

adhesiveness, therefore it is not surprising to find remaining filling material at the apical third. The retreatment technique together with apical anatomical complexity could also explain the findings. The use of a sealer containing calcium hydroxide was an important variable in this study, since the literature is scarce as to the use of this material in such circumstances. Together with that, aging also affects the ability of sealer removal (Duarte et al, 2010).

Most studies did not detect differences between hand and rotary instrumentation with different sealers considering the total canal area (Schirrmeister et al., 2006b,c), possibly as a result of nonuse of solvent. Although the findings of the present study are consistent, extrapolation to the clinical condition should be done with care. Further research is necessary for this system to be used in a safer and more effective manner for endodontic retreatment.

CONCLUSIONS

Under the present experimental conditions debris were left in all canal thirds, regardless of the type of sealer. The greatest differences between techniques and sealers were found in the cervical third.

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