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ORIGINAL ARTICLE

Comparing ProFile Vortex to ProTaper Next for the efficacy of removal of root filling material: An *ex vivo* micro-computed tomography study

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Abstract *Aim:* This study compared the efficacy of ProFile Vortex (PV) with that of ProTaper Next (PTN) for the removal of root canal filling material.

Materials and methods: Twenty-six mesial canals of extracted mandibular first molars were instrumented, obturated with gutta-percha and sealant, and randomly allocated to a PTN (X3, X2, or X1) or PV group. The percentage of remaining material, amount of dentin removed, and extent of transportation were assessed using micro-computed tomography. The total time required for removal of material was calculated.

Results: Both systems were effective for material removal ($p \leq 0.001$). Less time was required to remove material using PV (256.43 ± 108.95 s) than using PTN (333.31 ± 81.63 s; $p \leq 0.05$). PV and PTN files removed approximately 84% and 78% of the filling material, respectively ($p >$ .05). There was no significant canal transportation in either group. PV and PTN files removed 1.32 ± 0.48 mm^3 and 1.63 ± 0.67 mm^3 of the dentin, respectively (p = .18).

Conclusion: Our findings suggest that PV is as effective as PTN for removal of root canal filling material. Therefore, PV can be considered for use in endodontic retreatment, although more effective files or techniques are still required.

1. Introduction

Nonsurgical endodontic retreatment is considered to be the first choice of treatment after failed root canal therapy (Stabholz and Friedman, 1988). However, it is a challenging procedure, particularly in cases of curved canals (Schirrmeister et al., 2006). After gaining access to the canal, the crucial step in retreatment is removal of the old filling material and measurement of the correct working length (WL) (Stabholz and Friedman, 1988; Haapasalo and Ricucci, 2008).

Complete removal of the previous filling material is required to eliminate bacteria that may be harbored within the material, which cannot be reached by antimicrobial solutions and compromise the seal of the new filling material

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(Ricucci et al., 2009; Siqueir, 2011). Remnant bacteria within the apical sites of the canal contribute significantly to persistent inflammation in the periradicular areas (Ricucci et al., 2009). Several methods for removal of gutta-percha from root canals, including chemical, thermal, and/or mechanical instrumentation, have been tested (Friedman et al., 1990). However, none of these methods have been proven to be successful for complete removal of gutta-percha and sealer from the canal (Zmener et al., 2006; Duncan, 2008, de Mello Junior et al., 2009; Rios Mde et al., 2014; Keles et al., 2015). Nickel-titanium rotary instruments are used to prepare and shape root canals (Walia et al., 1988), and different designs of these instruments have been developed specifically for removal of gutta-percha during retreatment (Gu et al., 2008).

Recently, the ProFile Vortex (PV) system (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA) was introduced and is characterized by a triangular cross-section and manufactured using innovative M-wire technology (Alapati et al., 2009; Gao et al., 2010).

Subsequently, the ProTaper Next (PTN) system (Dentsply Tulsa Dental Specialties) was manufactured using the same M-wire technology used for PV files. This file is characterized by a rectangular cross-section and produces a unique asymmetric rotary motion (Ruddle et al., 2013).

Several reports have investigated the efficiency of PTN systems for removal of root canal filling materials and compared the results with those for different rotary and reciprocating files (Nevares et al., 2016; Ozyurek and Demiryurek, 2016). However, although the physical properties and material performance of PV systems have been investigated, there is limited information on their effectiveness in endodontic retreatment (Yamamura et al., 2012; Zhao et al., 2014).

The aim of the present study was to compare the efficacy of the ProTaper Next system with that of the ProFile Vortex system for removal of root canal filling material in terms of the amount of dentin removed, percentage of remaining material, extent of transportation, and time required to remove the material completely.

The null hypothesis was that there would be no significant difference in the efficacy of the ProFile Vortex and ProTaper Next systems for removal of root canal filling, time needed to complete the procedure, or in apical transportation during endodontic retreatment.

2. Materials and methods

2.1. Sample selection

Fifty-two extracted human mandibular first molars were screened for inclusion in the study; the reasons for extraction were not considered to be relevant to the study. The primary screening procedures used to evaluate morphology and apply inclusion criteria included surgical microscopy, periapical radiography in the mesiodistal and buccolingual directions (Vertucci's class IV) (Vertucci, 1984), and micro-computed tomography (μCT).

Teeth with caries, abnormal, dilacerated, cracked, or resorbed roots, and/or a history of root canal treatment were excluded. Thirteen teeth with two completely separate mesial canals, two separate apical foramina, and curvatures of less than 25° as determined by the Schneider method (Barletta et al., 2007) were included. The mean (± standard deviation) angle of curvature was 15.69° ± 3.46°. All teeth were stored in 0.1% thymol solution at room temperature. A single operator performed and conducted the study.

2.2. Sample and root canal preparation

The sample preparation protocol followed that used in a previous study (Gambill et al., 1996). In brief, standardized access cavities were prepared and the patency of the mesial canals was assessed using a #10 K-file (Dentsply Maillefer, Baillaigues, Switzerland). Using a dental operating microscope (OPMI Pico; Carl Zeiss, Oberkochen, Germany), the WL was determined by insertion of a #10 K-file into the canal until its tip could be visualized through the apical foramen. The WL was measured up to 1 mm from the apical foramen. To standardize the samples, all teeth were decoronized to achieve a unified WL of 18 mm. Customized silicone mounts were prepared to accurately position and standardize each specimen for μCT. Once a glide path was achieved, all canals were instrumented by continuous rotation using a ProTaper Universal system (Dentsply Maillefer) as recommended by the manufacturer to size an F3 file to the full WL. All canals were copiously irrigated with 5.25% sodium hypochlorite solution after each filing cycle. The smear layer was removed by irrigation with 17% ethylene diamine tetraacetic acid followed by 5.25% sodium hypochlorite as the final rinse.

2.3. Root canal filling

All canals were dried with paper points and filled using F3 gutta-percha cones with tips that were coated with AH-Plus sealer (Dentsply Detrey, Konstanz, Germany). A heated plugger (Alpha; B&L Biotech Inc., CA, USA) was introduced into the canal for 5 mm of WL, following which the entire canal was back-filled with gutta-percha in a continuous wave using the Beta obturation system (B&L Biotech Inc.). The quality of obturation was assessed on periapical radiographs obtained in the mesiodistal and buccolingual directions. The sample was replaced if voids were detected. All specimens were stored at 37 °C and 100% humidity for 15 days to allow the root canal sealer to set.

2.4. Preoperative micro-CT

Following obturation, all specimens were scanned preoperatively using a Skyscan 1172 micro-CT device (Bruker microCT, Kontich, Belgium) under the following conditions: source voltage, 100 kV; source current, 100 μA; 360° rotations around the vertical axis; isotropic resolution, 13.73 μm; camera exposure time, 1700 ms; and rotation step, 0.4°. X-rays were filtered with a 0.5-mm-thick aluminum and 0.5-mm-thick copper filter for changes in sensitivity of the polychromatic radiations. The raw images were then reconstructed using NRecon version 1.6.4 software (Bruker microCT), under the following conditions: smoothing, 5; smoothing kernel, 2 (Gaussian); ring artifact correction, 15; and beam hardening correction, 40%. CTan v1.11.10.0 software (Skyscan, Bruker microCT) was used for three-dimensional image reconstruction and measurement of the material volume in each canal.