Micro–computed Tomographic Assessment on the Effect of ProTaper Next and Twisted File Adaptive Systems on Dentinal Cracks

Gustavo De-Deus, DDS, MSc, PhD, Felipe Gonçalves Belladonna, DDS, MSc,† Erick Miranda Souza, DDS, MSc, PhD,‡ Emmanuel João Nogueira Leal Silva, DDS, MSc, PhD,* Aline de Almeida Neves, DDS, MSc, PhD,§ Haimon Alves, MSc,|| Ricardo Tadeu Lopes, MSc, DSc,|| and Marco Aurélio Versiani, DDS, MSc, PhD¶*

Abstract

Introduction: The aim of the present study was to evaluate the frequency of dentinal microcracks observed after root canal preparation with ProTaper Next (PTN; Dentsply Maillefer, Ballaigues, Switzerland) and Twisted File Adaptive (TFA; SybronEndo, Orange, CA) systems through micro–computed tomographic analysis. **Methods:** Twenty moderately curved mesial roots of mandibular molars presenting a type II Vertucci canal configuration were randomly assigned to 2 experimental groups ($n = 10$) according to the system used for the root canal preparation: PTN or TFA systems. The specimens were scanned through high-resolution micro–computed tomographic imaging before and after root canal preparation. Afterward, pre- and postoperative cross-sectional images of the mesial roots ($N = 25{,}820$) were screened to identify the presence of dentinal defects. **Results:** Dentinal microcracks were observed in 38.72% ($n = 5150$) and 30.27% ($n = 3790$) of the cross-sectional images in the PTN and TFA groups, respectively. All dentinal defects identified in the postoperative scans were already present in the corresponding preoperative images. **Conclusions:** Root canal preparation with PTN and TFA systems did not induce the formation of new dentinal microcracks. *(J Endod 2015;41:1116–1119)*

Key Words

Dentinal defects, microcracks, micro–computed tomographic imaging, root canal preparation, rotary system

The development of new nickel-titanium (NiTi)-based root canal preparation systems, such as the recently launched ProTaper Next (PTN; Dentsply Maillefer, Ballaigues, Switzerland) and Twisted File Adaptive (TFA; SybronEndo, Orange, CA) systems, has been primarily based on changes in the instrument design, alloy, and kinematics.

The PTN system is composed of 3 instruments made of a unique NiTi alloy and M-wire manufactured through a thermal treatment process and incorporates a variable taper design and a unique offset mass of rotation, which improve the strength and flexibility along its active part. According to the manufacturer, the design of PTN results in an asymmetric rotary motion intended to decrease the screw effect by minimizing the contact area between the file and the dentinal wall (1), enhancing the apical control of extruded debris (2, 3). The TFA system has been developed with 3 design features, namely R-phase heat treatment, twisting of the metal, and special surface conditioning (4), which are claimed to enhance strength, flexibility, and resistance to fatigue (5), minimizing transportation even in severely curved root canals (6–8). TFA instruments are driven by a dedicated motor (Elements Adaptive motor, SybronEndo) that automatically adapts the motion to a continuous rotary or reciprocating movement depending on the frictional intracanal stress over the instrument during root canal preparation.

Several studies have reported the development of dentinal defects, such as microcracks and craze lines, after root canal preparation with NiTi-based instruments (9–15). These dentinal defects can stand as a trigger point for vertical root fractures (16–19) and may influence the long-term survival of endodontically treated teeth. Recently, using destructive sectioning technique methodology, Capar et al (9) showed that PTN caused fewer dentinal cracks compared with the ProTaper Universal system (Dentsply Maillefer). So far, neither PTN nor TFA was assessed regarding dentin microcrack formation through nondestructive imaging technology. Thus, this study aimed to evaluate the percentage frequency of dentinal microcracks observed after root canal preparation with PTN and TFA systems using high-resolution micro–computed tomographic (micro-CT) analysis. The null hypothesis tested was that root canal preparation with PTN and TFA systems is unable to create new dentin microcracks.

From the *Department of Endodontics, Grande Rio University, Duque de Caxias, Rio de Janeiro; †Department of Endodontics, Fluminense Federal University, Niterói, Rio de Janeiro; ‡Department of Dentistry II, Federal University of Maranhão, São Luís, Maranhão; §Department of Pediatric Dentistry and Orthodontics, Federal University of Rio de Janeiro, Rio de Janeiro; ||Nuclear Engineering Program, Federal University of Rio de Janeiro, Rio de Janeiro; and ¶Department of Restorative Dentistry, Dental School of Ribeirão Preto, University of Sao Paulo, Ribeirão Preto, Brazil.

Address requests for reprints to Prof Gustavo De-Deus, Av Henrique Dodsworth, 85, Apto 808, Lagoa, Rio de Janeiro, RJ 22061-030. E-mail address: endogus@gmail.com

0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2015.02.012

Materials and Methods

Sample Size Calculation

The total sample size for this study was calculated after the effect size estimation of dentinal defects (7.6) promoted by rotary and reciprocating systems as reported previously (10) in which the percentage sum of the specimens with complete and incomplete dentinal cracks ranged from 18.3%–51.6%. Eight samples were indicated by the chi-square test family and variance statistical test (G*Power 3.1 for Macintosh; Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) with $\alpha = 0.05$ and $\beta = 0.95$ as the minimum size required for observing the same effect of instruments over dentin.

Sample Selection

After the approval of the ethical committee, 175 human mandibular first and second molars with completely separated roots and extracted for reasons not related to this study were obtained from a pool of teeth. All roots were initially inspected with a stereomicroscope under 12× magnification to detect and exclude teeth with any visible pre-existing craze lines or cracks. Then, a digital radiograph was taken in the buccolingual direction to visualize possible root canal obstructions and to determine the curvature angle of the mesial root (20). Only teeth with moderate curvature of the mesial root (ranging from 10°–20°) in which the root canals were patent to the length with a size 10 K-file (Dentsply Maillefer) were selected. Specimens were decoronated, and distal roots were removed by using a low-speed saw (Isomet; Buhler Ltd, Lake Bluff, NY) with water cooling, leaving mesial roots with approximately 12 ± 1 mm in length to prevent the introduction of confounding variables. As a result, 88 specimens were selected and stored in 0.1% thymol solution at 5°C.

To attain an overall outline of the canal anatomy, the mesial roots were prescanned in a relatively low isotropic resolution (70 μm) using a micro-CT scanner (SkyScan 1173; Bruker microCT, Kontich, Belgium) at 70 kV and 114 mA. Based on the 3-dimensional models of the root canal achieved from these prescan set of images, 20 specimens with a type II Vertucci canal configuration (21) were selected. Then, these roots were scanned again at an increased isotropic resolution of 14.25 μm using 360° rotation around the vertical axis, a rotation step of 0.5°, camera exposure time of 7000 milliseconds, and frame averaging of 5. X-rays were filtered with a 1-mm-thick aluminum filter. Images were reconstructed with NRecon v.1.6.9 software (Bruker microCT) using 40% beam hardening correction and ring artifact correction of 10, resulting in the acquisition of 700 to 800 transverse cross-sections per tooth.

Root Canal Preparation

The surface of the roots were coated with a thin film of polyether impression material to simulate the periodontal ligament (11) and placed coronal apically inside a custom-made epoxy resin holder (Ø = 18 mm) to further streamline the coregistration process. Apical patency was confirmed by inserting a size 10 K-file into the root canal until its tip was visible at the apical foramen, and the working length (WL) was set 1.0 mm shorter of this measurement. The glide path was established with a size 15 K-file (Dentsply Maillefer) up to the WL, and the specimens were randomly assigned to 2 experimental groups ($n = 10$) according to the system used for the root canal preparation: PTN and TFA groups.

In the PTN group, X1 and X2 (25/0.06) instruments serially enlarged the root canal with a slightly brushing motion (300 rpm, 200 N·cm torque) away from the root concavities powered by the VDW Silver motor (VDW, Munich, Germany). In the TFA group, SM1 and SM2 (25/0.06) instruments were used sequentially with a single controlled motion (TFA program) of the Elements Adaptive motor (SybronEndo) according to the manufacturer's instructions. Considering that the TFA system does not preconize the use of an exclusive file for coronal flaring, the SX file from the ProTaper system was not used herein.

All instruments were used at the WL; after which, the patency was rechecked with a size 10 K-file. The root canal preparations were performed by a single experienced operator and deemed complete when the final instrument of each system had reached the WL. In both groups, irrigation was performed using a total of 40 mL 5.25% sodium hypochlorite per canal. After preparation, a postoperative micro-CT scan of each specimen was performed using the aforementioned parameters.

Dentinal Microcrack Evaluation

An automatic superimposition process based on the outer root contour using 1000 interactions with Seg3D v.2.1.5 software (SCI Institute's National Institutes of Health/National Institute of General Medical Sciences CIBC Center, Bethesda, MD) coregistered the image stacks of the specimens before and after canal preparation. Then, 3 precalibrated examiners screened the cross-sectional images of the mesial roots, from the furcation level to the apex ($N = 25{,}820$), to identify the presence of dentinal microcracks. First, the postoperative images were analyzed, and the number of the cross sections in which dentinal defects had been observed was recorded. Afterward, the preoperative corresponding cross-sectional images were also examined to verify the pre-existence of the dentinal defect observed in the postoperative counterpart. To validate the screening process, image analyses were repeated twice at 2-week intervals; in case of divergence, the image was examined together until an agreement was reached (22).

Results

From a total of 25,820 slices, 34.62% (8940 slices) had some dentinal defect. Microcracks were observed in 38.72% ($n = 5150$) and 30.27% ($n = 3790$) of the cross-sectional images in the PTN and TFA groups, respectively. All dentinal defects identified in the postoperative scans were already present in the corresponding preoperative images (Fig. 1). Thus, no new microcrack was observed after root canal instrumentation with the tested systems.

Discussion

In the current study, the effect of 2 recently developed NiTi systems (PTN and TFA) regarding the incidence of dentinal defects created during root canal preparation was evaluated. In both groups, all dentinal microcracks observed in the postoperative cross-sectional images already existed in the corresponding preoperative image. Therefore, mechanical enlargement procedures could not be associated with the formation of new cracks. This result markedly contrasts with several previous publications that have shown a clear correlation between root canal preparation and the initiation and/or propagation of dentinal microcracks (9–13). Yoldas et al (12) tested the full sequence of the ProTaper Universal system (SX–F3) in mesial canals of mandibular molars and observed dentin defects in 30% of the sample ($n = 6$). Similarly, Bürklein et al (10) found that ProTaper Universal full-sequence rotary instruments caused microcracks in a rate of 23.3% in mandibular incisors, whereas Capar et al (9) observed cracks in 28% of roots instrumented with the PTN system. In these studies, the generation of dentinal defects has been associated with differences in the instrument design and kinematics, which is not in accordance with the present results and a similar previous publication (22) using a micro-CT approach.