Canal Shaping with WaveOne Primary Reciprocating Files and ProTaper System: A Comparative Study

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Abstract

Introduction: This study compared the canal curvature and axis modification after instrumentation with WaveOne Primary reciprocating files (Dentsply Maillefer, Ballaigues, Switzerland) and nickel-titanium (NiTi) rotary ProTaper (Dentsply Maillefer). **Methods:** Thirty ISO 15, 0.02 taper, Endo Training Blocks (Dentsply Maillefer) were used. In all specimens, the glide path was achieved with PathFile 1, 2, and 3 (Dentsply Maillefer) at the working length (WL). Specimens were then assigned to 1 of 2 groups for shaping: specimens in group 1 were shaped with ProTaper S1-S2-F1-F2 at the WL and specimens in group 2 were shaped with WaveOne Primary reciprocating files at the WL. Pre- and postinstrumentation digital images were superimposed and processed with Matlab r2010b (The MathWorks Inc, Natick, MA) software to analyze the curvature-radius ratio (CRr) and the relative axis error (rAe), representing canal curvature modification. Data were analyzed with one-way balanced analyses of variance at 2 levels ($P < .05$). **Results:** The instrument factor was extremely significant for both the CRr parameter ($F_1 = 9.59$, $P = .004$) and the rAe parameter ($F_1 = 13.55$, $P = .001$). **Conclusions:** Canal modifications are reduced when the new WaveOne NiTi single-file system is used. *(J Endod 2012;38:505–509)*

Key Words

Canal shaping, nickel-titanium, ProTaper, reciprocating motion, WaveOne

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Root canal shaping is one of the most important steps in canal treatment (1). It is essential in determining the efficacy of all subsequent procedures, including chemical disinfection and root canal obturation (2). However, even if this stage is adversely influenced by the highly variable root canal anatomy (3), it aims to achieve complete removal of the vital or necrotic tissue to create sufficient space for irrigation (2, 4). Furthermore, shaping tends to preserve the integrity and location of the canal and apical anatomy in preparation for an adequate filling (2, 5, 6). The avoidance of both iatrogenic damage to the root canal structure and further irritation of the periradicular tissue is demanding for all the newest instrumentation techniques (2, 7). Maintaining the original canal shape using a less invasive approach is associated with better endodontic outcomes (1). Previous studies have shown that canal transportation leads to inappropriate dentine removal, with a high risk of straightening the original canal curvature and forming ledges in the dentine wall (8, 9). Nickel titanium (NiTi) rotary instruments have shown efficiency in achieving optimal root canal shaping (1, 10), with less straightening and better centered preparations of curved root canals (2). The superelasticity of NiTi rotary files may allow less lateral forces to be exerted against the canal walls, especially in severely curved canals, reducing the risk of canal aberrations and better maintaining the original canal shape (1, 11). However, in clinical practice, these instruments may be subjected to fracture, mainly because of flexural (fatigue fracture) and torsional (shear failure) stresses (12–14). Torsional stresses may be increased with a wide area of contact between the canal walls and the cutting edge of the instrument (3, 15). To reduce such stresses, the ProTaper rotary design combines multiple progressive tapers, adequately maintaining the original canal curvature (1, 16, 17). Canal curvature is suspected to be the predominant risk factor for instrument failure because of flexural stresses and cyclic fatigue (1–3). The clinician can do very little to prevent or reduce such stresses. The reciprocating motion of the NiTi rotary instrument has been shown to decrease the impact of cyclic fatigue compared with rotational motion (18–20). Therefore, it has been recently proposed that the single-file shaping technique may simplify instrumentation protocols and avoid the risk of cross-contamination. Moreover, the use of only one NiTi instrument is more cost-effective, and the learning curve is considerably reduced (20).

The new WaveOne NiTi single-file system has been recently introduced by Dentsply Maillefer (Ballaigues, Switzerland) (21). The system is designed to be used with a dedicated reciprocating motion motor. It consists of 3 single-use files: small (ISO 21 tip and 6% taper) for fine canals, primary (ISO 25 tip and 8% taper) for the majority of canals, and large (ISO 40 and 8% taper) for large canals. The files are manufactured with M-Wire (Dentsply Tulsa Dental Specialties, Tulsa, OK) NiTi alloy (22). The WaveOne Primary file has the same tip size and taper features as the ProTaper F2 but a variable section and reverse cutting blades. The purpose of this study was to compare the ability of the WaveOne Primary file with the ProTaper system up to F2 rotary file in preserving canal anatomy.

Materials and Methods

Thirty ISO 15, 0.02 taper, Endo Training Blocks (Dentsply Maillefer) were used. Each simulated canal was colored with ink injected with a syringe. In each block, landmarks were placed 3 mm from the 4 corners of the side of interest. Each specimen was mounted on a stable support consisting of a rectangular slot the size of the specimen (30 × 10 mm) and a support for a digital camera (Nikon D70; Nikon, Tokyo, Japan) positioned centrally and at 90° to the specimen. Digital images of all specimens before instrumentation were obtained and saved as JPEG files. Specimens were then randomly assigned to 2 different groups (n = 15 each).

In group 1, the glide path was created with PathFile 1, 2, and 3 (Dentsply Maillefer) at the full working length (WL) using Glyde (Dentsply Maillefer) as the lubricating agent. Each canal was shaped using ProTaper S1-S2, and then the WL was checked and shaping was accomplished with F1-F2 at the WL with the X-Smart motor (Dentsply Maillefer) set to 300 rpm and a 5-Ncm torque with a 16:1 contra-angle. Canal patency was checked with a #10 K-file (Dentsply Maillefer) before the glide path, after the glide path, before using ProTaper S1, and after ProTaper S2 but before using the F1-F2 finishing files.

In group 2, the glide path was created with PathFile 1, 2, and 3 at the full WL by using Glyde as the lubricating agent. Canals were shaped with WaveOne Primary reciprocating files using a pecking motion. The WL was checked when the instrument had reached the limit between the middle and apical third, and then shaping was accomplished at that the definitive WL. The dedicated reciprocating motor (Dentsply Maillefer) of the WaveOne file was used with the manufacturer configuration setup. Canal patency was checked with a #10 K-file (Dentsply Maillefer) before the glide path, after the glide path, and before using WaveOne Primary, and when WaveOne Primary had reached the limit between the middle and the apical third before completing shaping at the full WL.

All specimens were prepared by the same expert operator who is competent in both instrumentation techniques. New instruments were used in each specimen. After use, each instrument was observed under a magnification of 3.5× loupes by a different expert operator and compared with a new instrument in order to detect any macroscopic deformation. After instrumentation, all specimens in each group were repositioned in the slot and photographed as described previously. By using digital imaging software (Adobe Photoshop CS4; Adobe Systems Inc, San Jose, CA), the preinstrumentation digital images were superimposed on the postinstrumentation images, taking the landmarks as reference points (Fig. 1, Stage 1). Images were magnified and cropped to focus on the canal geometry. The edges of each preinstrumented (initial) and postinstrumented (final) canal were automatically detected by means of Adobe Photoshop automatic tools, and the edges of each initial canal were processed separately from the edges of the corresponding final canal. The area within edges was colored in white, whereas the area outside the edges was colored in black. Images were finally saved in a black and white .tiff format (Fig. 1, Stage 2).

Black and white images were then imported in Matlab r2010b software (The MathWorks Inc, Natick, MA) for mathematic processing. A software program was written in Matlab code in order to automatically (1) identify the mean axis of each canal (Fig. 1, Stage 3) and (2) determine the osculating circle that best fits the mean axis of each canal (Fig. 1, Stage 4).

In particular, an arc corresponding to 45° was considered for the optimal fit algorithm, and the correlation coefficients were larger than 99.99%. By considering the fitted osculating circles, both the curvature radius of each initial canal (CRi) and the curvature radius of the corresponding final canal (CRf) were obtained, and the geometric parameter called the curvature-radius ratio (CRr) was computed for each canal as CRr = 100 · CRf/CRi. The closer the CRr parameter is to the value 100, the smaller the canal shape modifications caused by the instrumentation.

As shown in Figure 2, another geometric parameter identified as the relative axis error (rAe) was computed in order to better investigate canal modifications induced by instrumentation. In particular, to obtain the value of rAe for each canal, the following actions were performed: (1) superimposition of the initial and the final osculating arcs; (2) determination of $\Delta\theta$ (ie, the angle with vertex in the center of the initial osculating circle for which both the initial and the final osculating arcs coexist; (3) numeric computation of the axis error (Ae) (ie, the area enclosed by the initial and the final osculating arcs [Fig. 2, magnification]); and (4) computation of rAe as rAe = 100 · Ae/CSi, where CSi denotes the circular sector corresponding to $\Delta\theta$ (ie, CSi = $CRi^2 \cdot \Delta\theta/2$). Therefore, the smaller the rAe, the less the canal shape had been modified by instrumentation.

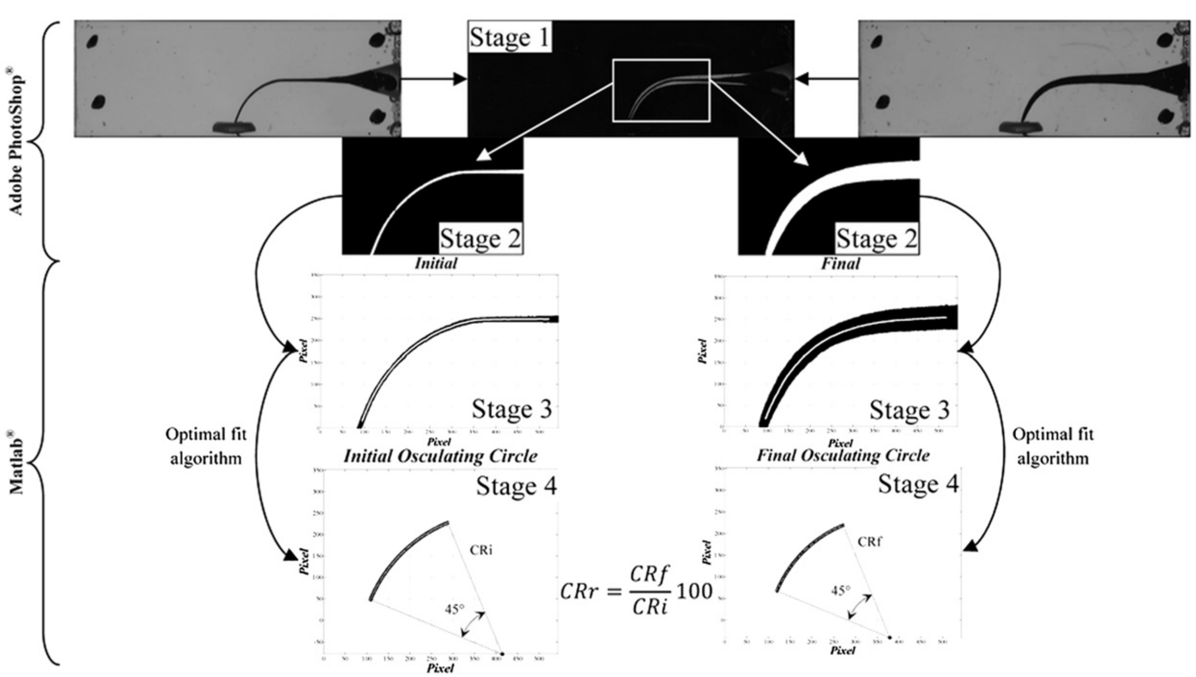

Figure 1. A schema to determine the CRr parameter.