Root Canal Anatomy Preservation of WaveOne Reciprocating Files with or without Glide Path

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Abstract

Introduction: This study evaluated the influence of glide path on canal curvature and axis modification after instrumentation with WaveOne Primary reciprocating files. **Methods:** Thirty ISO 15, 0.02 taper Endo Training Blocks were used. In group 1, glide path was created with PathFile 1, 2, and 3 at working length, whereas in group 2, glide path was not performed. In both groups, canals were shaped with WaveOne Primary reciprocating files at working length. Preinstrumentation and postinstrumentation digital images were superimposed and processed with Matlab r2010b software to analyze the curvature radius ratio (CRr) and the relative axis error (rAe), representing canal curvature modification. Data were analyzed with 1-way balanced analyses of variance at 2 levels ($P < .05$). **Results:** Glide path was found to be extremely significant for both CRr parameter ($F = 9.59$; $df = 1$; $P = .004$) and rAe parameter ($F = 13.55$; $df = 1$; $P = .001$). **Conclusions:** Canal modifications seem to be significantly reduced when previous glide path is performed by using the new WaveOne nickel-titanium single-file system. *(J Endod 2012;38:101–104)*

Key Words

Glide path, nickel-titanium, pathfile, reciprocating motion, WaveOne

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Nickel-titanium (NiTi) rotary instruments were introduced to improve root canal preparation (1). In clinical practice these instruments are associated with an increased risk of fracture, mainly because of bending normal stresses (failure by fatigue) and torsional shear stresses (failure by torque) (2–4). Failure by torque might occur in case of torsional shear stresses exceeding the elastic limit of the alloy, producing plastic deformation and eventually fracture (4). The clinician and the type of instrumentation are fundamental to prevent torsional shear stresses. Various aspects might contribute to increase these stresses, such as excessive pressure on the handpiece (5), a wide area of contact between the canal walls and the cutting edge of the instrument (6, 7), or if the canal section is smaller than the dimension of the nonactive or noncutting tip of the instrument (6, 7); the latter case might lead to a taper lock, especially with regularly tapered instruments (8). The risk of taper lock might be reduced by performing coronal enlargement (9, 10) and creating a glide path before using NiTi rotary instrumentation (11, 12), both manual and mechanical (13). Thus, the root canal diameter should be bigger than or at least the same size as the tip of the first rotary instrument used (11–13). Canal curvature is considered one of the major risk factors for instrument failure caused by bending cyclic fatigue (1); stresses due to bending cannot be significantly influenced by the clinician.

The reciprocating motion might decrease the impact of cyclic fatigue on NiTi rotary instrument, compared with rotational motion (14, 15). The new WaveOne NiTi single-file system has been recently introduced by Dentsply Maillefer. 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 NiTi alloy (16). WaveOne clinical procedure (17) does not contemplate the preliminary creation of a glide path before use. WaveOne Small is suggested when a #10 K-file is very resistant to the movement when reaching full working length (WL); WaveOne Primary is indicated when a #10 K-file moves to length easily, and WaveOne Large when a #20 K-file or larger goes to length (17).

The aim of the study was to compare modification of the canal curvature and axis with the new WaveOne single-file reciprocating system in Endo Training Blocks, with and without glide path.

Materials and Methods

Thirty ISO 15, 0.02 taper Endo Training Blocks (Dentsply Maillefer, Ballaigues, Switzerland) were used. Each simulated canal was colored with ink injected with a syringe. Four landmarks were placed in each block. Each specimen was then 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, Tokyo, Japan), positioned centrally and at 90° to the specimen. Digital images of all specimens before instrumentation were obtained and saved as .jpeg format files. Specimens were then randomly assigned to 2 different groups (n = 15).

In group 1, the mechanical glide path was performed by using Glyde (Dentsply Maillefer) as a lubricating agent, with NiTi rotary instruments PathFile (PF) (Dentsply

Maillefer). The system consists of 3 instruments with 21-, 25-, and 31-mm length and 0.02 taper; they have square section. PF #1 (purple) has an ISO 13 tip size; PF #2 (white) has an ISO 16 tip size; and PF #3 (yellow) has an ISO 19 tip size. PF #1 was used immediately after #10 hand K-file had been used to scout the root canal to full WL by using an endodontic engine (X-Smart; Dentsply Maillefer) with 16:1 contra angle at the suggested setting (300 rpm on display, 5 Ncm) at full WL; then PF #2 and PF #3 were used at WL. Each canal was then shaped with WaveOne Primary reciprocating files (Dentsply Maillefer), used with a pecking motion, until reaching full WL. The WaveOne dedicated reciprocating motor was used with the manufacturer configuration set-up.

In group 2, glide path was not performed. Each canal was shaped with WaveOne Primary reciprocating files, used with a pecking motion until reaching full WL, by using Glyde as lubricating agent. After instrumentation, all specimens in each group were repositioned in the slot and photographed as described above.

By using digital imaging software (Adobe Photoshop CS4; Adobe Systems Inc, San Jose, CA), the preinstrumentation digital images were superimposed over the postinstrumentation images, taking the landmarks as reference points (Fig. 1, stage 1). Images were magnified and cropped to make evident the geometry of the canal. The edges of each preinstrumented (initial) and postinstrumented (final) canal were automatically detected by means of Adobe Photoshop automatic tools, and edges of each initial canal were processed separately from edges of the corresponding final canal. Afterwards, each area enclosed by edges was filled out with white color, whereas each area outside the edges was filled out with black color. The final images were saved in black and white .tiff format (Fig. 1, stage 2).

The black and white images were then imported in Matlab r2010b software (The MathWorks Inc, Natick, MA) for mathematical processing. A software program was written in Matlab code 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 always 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 geometrical parameter curvature radius ratio (CRr) was computed for each canal as CRr = 100 · CRf/CRi. Thus, the more the CRr parameter approaches the value 100, the smaller the canal shape modification induced by the instrumentation.

As shown in Figure 2, another geometrical parameter defined as the relative axis error (rAe) was computed. This parameter enabled to better investigate canal modifications induced by instrumentation. To assess the value of rAe for each canal, the following steps 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), that is, 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.

Two 1-way balanced analyses of variance were performed to investigate canal modifications induced by instrumentation and to evaluate the significance of the glide path factor on both CRr and rAe at 2 levels, with (Y) and without (N) glide path. The significance level was set to 5% ($P < .05$). All statistical analyses were performed by using the Minitab 15 software package (Minitab Inc, State College, PA).

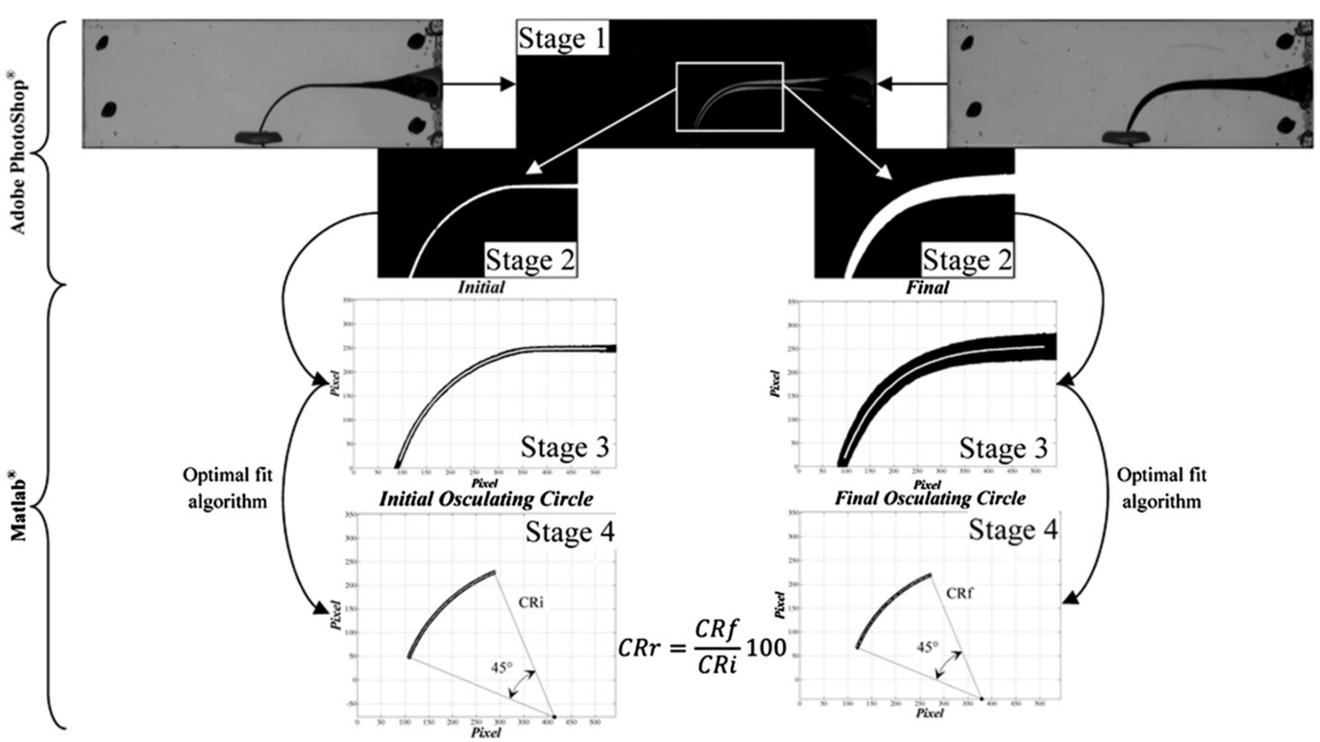

Figure 1. Scheme to determine the CRr parameter.

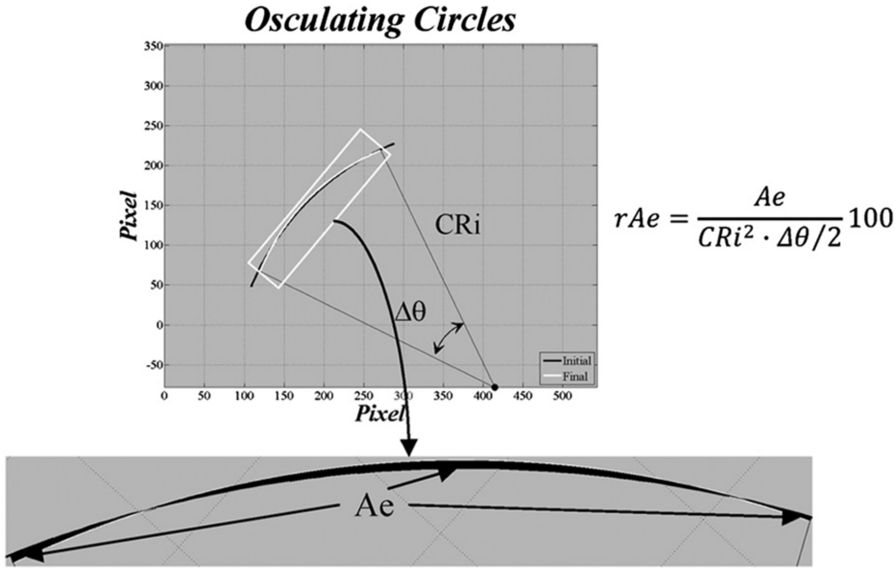

Figure 2. Scheme to determine the rAe parameter.

Results

Modification of Curvature

Glide path performance factor was extremely significant for both CRr parameter ($F = 9.59$; $df = 1$; $P = .004$) and rAe parameter ($F = 13.55$; $df = 1$; $P = .001$). The interval plots for the CRr parameter (Fig. 3*A*) and for the rAe parameter (Fig. 3*B*) graphically confirmed statistical significance of the glide path factor. If the glide path is performed (Y), then the CRr parameter is closer to the value 100 and the rAe parameter to 0 (ie, if canals are previously instrumented with a previous glide path, then canal modifications seem to be significantly reduced).

No macroscopic deformations or fractures of any instrument occurred during the experiment.

Discussion

The present study aimed to compare the shaping performance of the new WaveOne single-file reciprocating system in Endo Training Blocks, both with and without glide path. Even though they do not represent the anatomic variability of a human root canal system, simulated resin canals have been widely used to point out differences in performance of instruments under standardized experimental conditions (18). Studies suggested that the analysis of modifications in canal curvature after instrumentation is a reliable method to evaluate the tendency of a shaping technique to maintain the original canal anatomy or to straighten the curves (19).

In this study, a quantitative analysis was performed through observation of changes between preinstrumentation and postinstrumentation curvature. Previous studies demonstrated the reliability of the experimental method used and its effectiveness in representing changes in canal curvature and in extrapolating the results (13). The new WaveOne NiTi primary reciprocating file, if used after a previous glide path, produced less modification in canal curvature compared with the WaveOne alone, as actually suggested by the clinical procedure flowchart (17). WaveOne NiTi files appear to maintain the original canal anatomy, and the presence of a glide path of the canal further improves their performance.

Coronal enlargement (9) and preliminary creation of a glide path are fundamental for safer use of NiTi rotary instrumentation (11, 12). Furthermore, the preflaring of root canals would increase the accuracy of root canal length measurements with electronic apex locators (20). However, no data exist on the influence of glide path on the life of a reciprocating motion file. The new WaveOne NiTi reciprocating system has been recently introduced to simplify canal shaping (17). Only 1 single file is suggested to reach adequate root canal size and taper. Single use, reciprocating motion, and M-Wire alloy manufacturing are the main characteristics of these instruments. Reciprocating motion was proposed to increase canal centering ability as well as to reduce

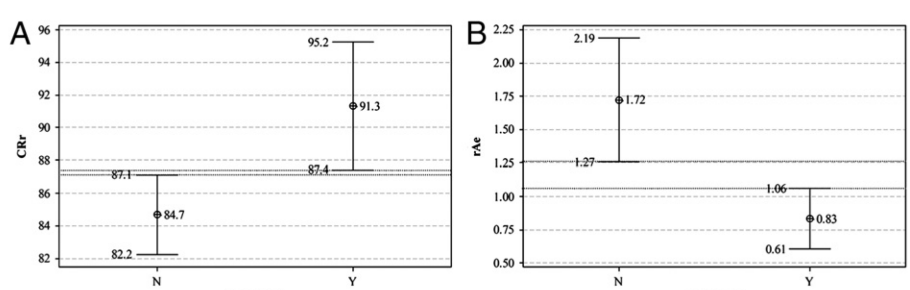

Figure 3. (*A*) Interval plot for CRr parameter; 95% confidence intervals for the mean. N, no glide path (group 2); Y, with glide path (group 1). (*B*) Interval plot for rAe parameter; 95% confidence intervals for the mean. N, no glide path (group 2); Y, with glide path (group 1). Complete separation of intervals indicates significant statistical difference between groups.

the risk of root canal deformity (21–23). Moreover, alternating rotary movement was improved to minimize torsional and flexural stresses, with a subsequent lower risk of instrument fracture (14, 15). Of note, the new M-Wire variant NiTi alloy instruments demonstrated better resistance on cyclic fatigue when compared with the same instrument design produced from stock 508 nitinol, preserving similar torsional properties (16). The single use of endodontic instruments was further supported to reduce instrument fatigue and possible cross-contamination associated with the use of NiTi rotary instruments for canal instrumentation (24).

Canal scouting and preflaring are the first phases of canal instrumentation during which the clinician might more frequently find procedural difficulties (25). The use of a small-size hand K-file followed by a more flexible and less tapered NiTi rotary PathFile might be a less invasive and safer method to provide a glide path that better maintains the original canal anatomy, compared with manual preflaring performed with stainless steel K-file (13). Moreover, preflaring tends to minimize procedural errors such as transportation and ledge formation. Indeed, preflaring permits to maintain a pathway to the full WL, avoiding excessive instrument binding in the canal (11, 12). In this study, it was observed that fewer pecking motions were needed to reach full WL with WaveOne single files, when previously glide path was performed. It might be hypothesized that this could reduce the risk of excessive undesired instrument brushing on the canal walls and subsequent root canal transportation (26–28). However, further studies are needed to investigate this aspect with multiple calibrated operators under standardized experimental conditions. Furthermore, canal aberrations might lead to inadequate shaping and filling, affecting negatively the disinfection and the long-term prognosis of the root canal therapy (1, 29).

Outer apical transportation and irregular foramen widening might lead to poor sealing efficiency with a high rate of extrusion of debris and postoperative discomfort (30–32). In this study the absence of a previous glide path affected the performance of WaveOne NiTi files, which evidenced greater alteration of the canal curvature, compared with the performance of WaveOne files with previous glide path. These findings suggest the clinical implication of root canal anatomy maintenance in susceptible anatomies. Excessive coronal flaring was found to increase the risk of strip perforation on the concave aspect of the curved roots (33). The mesial roots of the mandibular first molar are particularly subjected to strip perforation nearly 2 mm below the furcation (34). Because the amount of hard tissue among the inner curvature of these molars is less than 1.5 mm, transportation of the canal toward the furcation might perforate the root (34). Previous studies reported a lower thickness of the distal (furcal) root wall of the mesiobuccal canal of the maxillary molar in the longest teeth compared with shorter ones (35).

Within the limits of our study, it is possible to conclude that the creation of a previous glide path before any NiTi rotary or reciprocating motion instrumentation appears to be appropriate for safely shaping the canal.

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