Acta Odontologica Scandinavica. 2014; 72: 76–80

informa
healthcare

ORIGINAL ARTICLE

Comparision of two different preparation protocol of Ni-Ti Rotary PathFile-ProTaper instruments in simulated s-shaped canals

ELIF DELVE BAŞER CAN[1], MÜZEYYEN GEREK[2], MEHMET BAYBORA KAYAHAN[1], KAMBIZ MOHSENI[2], HAKKI SUNAY[1] & GÜNDÜZ BAYIRLI[2]

[1]*Department of Endodontics, Faculty of Dentistry, Yeditepe University, Istanbul, Turkey, and* [2]*Private Practice limited to Endodontics, Istanbul, Turkey*

Abstract

Introduction. The aim of this study is to compare the root canal transportation with the PathFile-ProTaper recommended protocol, PathFile-ProTaper modified protocol and stainless steel K-flexofiles. ***Methods.*** Forty-five ISO 15, 0.02 taper S-shaped Endo Training Blocks were divided randomly into three groups of 15 each and prepared as follows: PathFile-Protaper recommended protocol, Pathfile-Protaper modified protocol and manual preparation with K-Flexofiles. The amount of transportation was assessed by scanning the blocks before and after preparation and superimposing the images. The cutting effects of the instruments from the inner and outer aspects of the root canals were measured and statistically analyzed with the One-way Anova test and Tukey HSD test. ***Results.*** Manual preparation caused significantly more transportation than both PathFile-Protaper systems. There was no significant difference regarding transportation between the two Pathfile-Protaper protocols. ***Conclusion.*** The modified Pathfile-Protaper protocol transported the canal similar to the recommended Pathfile-Protaper protocol. It may be suggested that, while working safety remains unchanged, the shaping procedure and consequently working time can be shortened with fewer instruments. The results of this study can help clinicians to reduce the preparation time with the PathFile-ProTaper rotary system while the preparation quality remains the same.

Key Words: *Endodontics, PathFile, ProTaper, root canal transportation, S-shaped canals*

Introduction

Biomechanical preparation of the root canal system has been recognized as the critical part of the endodontic therapy. The aim of the biomechanical preparation is to eliminate bacteria and debris from the root canal system and to obtain a uniform shape for effective root canal filling [1]. However, achieving this goal may be difficult, especially in severely curved or S-shaped canals by stainless steel hand instruments.

During the cleaning and shaping procedure of curved root canals, a major cutting effect of the instruments is towards the inner aspect of the curvature, whereas it is towards the outer aspect at the apical third [2], that is a risk of canal transportation for all preparation techniques in curved canals [3]. Transportation of the canal from its original axis may result in elbow formation, which can be the reason of insufficient instrumentation, disinfection and incomplete filling of the root canal space.

The introduction of Ni-Ti rotary instruments has improved the quality of root canal preparations. However, it has also been reported that Ni-Ti instruments can straighten and transport the root canal from the original axis [4–6].

In narrow canals, especially in the apical part, if the tip of the Ni-Ti instrument encounters a portion of canal smaller than its diameter, the instrument tends to lock or undergoes structural failure [7]. However, it has been reported that pre-flaring and creation of a glide path has significantly reduced the incidence of ProTaper instruments breakage. Therefore, the root canal should be prepared to a diameter at least the same size as the tip of the first rotary instrument used [7,8]. When pre-flaring and creation of the manual glide path are performed especially by the general practitioner with stainless steel hand instruments,

Correspondence: Dr Elif Delve BaŞer Can, Yeditepe Universitesi Dis Hekimligi Fakultesi Endodonti AD, Bagdat cad. No:238 34728 Göztepe, Istanbul, Turkey. Tel: +0532 447 33 92; +02163636044/6268. Fax: +0216 363 62 11. E-mail: elif.baser@yeditepe.edu.tr

(Received 15 January 2013; accepted 10 May 2013)

ISSN 0001-6357 print/ISSN 1502-3850 online
DOI: 10.3109/00016357.2013.805430

Figure 1. Blocks were numbered and four landmarks were placed on each of them.

canal aberrations such as apical zips and elbow formation could occur more frequently [9]. Therefore, mechanical glide path formation was required and PathFile (Dentsply Maillefer, Ballaigues, Switzerland) has been developed to respond to this necessity.

PathFile rotary Ni-Ti instruments (Dentsply Maillefer) have been introduced to be used in combination with the ProTaper instruments (Dentsply Maillefer). The system consists of three instruments with square cross-section, the tip diameter of 0.13, 0.16, 0.19 mm, respectively, 0.02 constant taper and available at a 21, 25 and 31 mm length.

Root canals with multiple curves are common anatomic findings as well as easy straight root canals [3]. Creating a glide path becomes more challenging during instrumentation of such S-shaped canals. When PathFile instruments were first introduced to the market, a shaping protocol different from the current one was recommended which was named as a recommended protocol in the present study. Recently this protocol has been used for difficult canals. As the recommended protocol extends the chair time and increases the number of uses of PathFile instruments, it may be reasonable to shorten the recommended protocol without effecting shaping quality.

The aim of the present study is to compare the root canal transportation of the PathFile-ProTaper (PP) recommended protocol with the PathFile-ProTaper modified protocol and stainless steel K-Flexofiles in S-shaped canals. The null hypothesis is that there is no difference between the recommended and modified protocol in terms of canal transportation.

Materials and methods

Resin blocks

Forty-five ISO 15, 0.02 taper S-shaped Endo Training Blocks made of clear resin (Dentsply Maillefer) were used in this study. The specimens were divided randomly into three groups of 15 each and numbered from 1–15 and four landmarks were placed on each block (Figure 1). Each specimen was placed on a support consisting of a rectangular slot of the size of the specimen (30 × 10 mm) which was designed for the scanner.

Scanning of the resin blocks

Resin blocks were scanned with an Epson Expression 10000 XL-Photo Scanner (Seiko Epson, Long Beach, CA) at 2400 dpi resolution before and after preparation and saved as JPG format.

The images were analyzed with computer software (Adobe Photoshop CS5; Adobe Systems, San Jose, CA). They were magnified and the root canal spaces were outlined and filled automatically with different colors in pre- and post-instrumentation images. For evaluation of the transportation, 10 levels were defined equidistantly in each specimen, starting from the first curve to the working length and traced perpendicular to the long axis along the root canal. For evaluating the canal transportation accurately levels 1–5 were defined as coronal curvature (CC) while levels 5–10 were defined as apical curvature (AC).

Root canal preparation

In Group I, PathFile-ProTaper rotary instruments with recommended protocol were used, in Group II, PathFile-ProTaper rotary instruments with modified protocol were used and in Group III, Gates Glidden (GG) drills (Dentsply/Maillefer) and K-Flexofiles (Dentsply Maillefer) with step down technique were used. The length of the simulated canals were 17 mm and working length (WL) was determined as 16 mm. All shaping procedures were

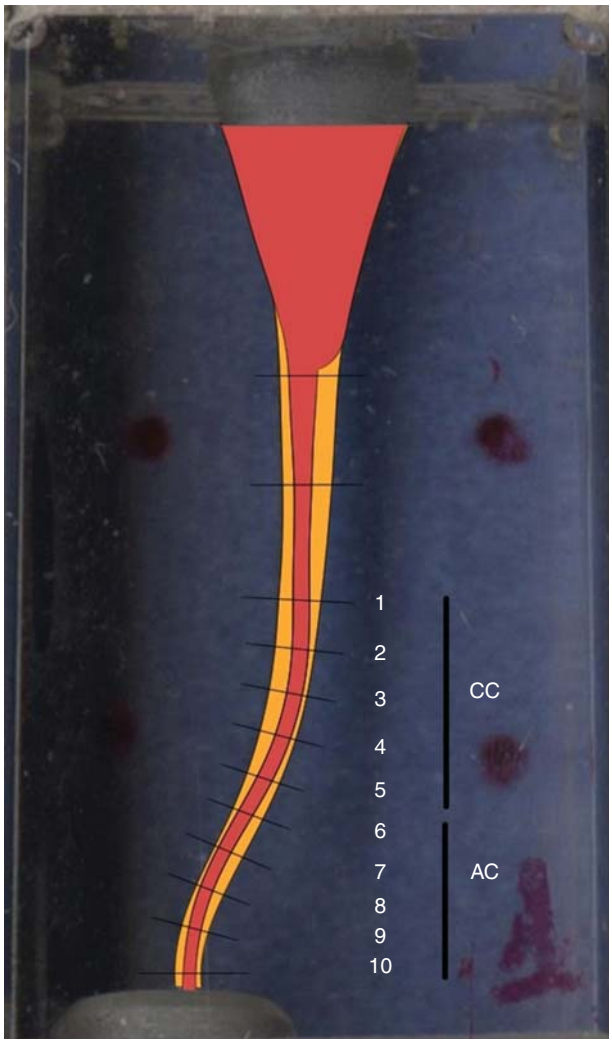

Figure 2. Pre-instrumentation and post-instrumentation images were superimposed and the difference between the canal configuration before and after instrumentation were measured in each one of the 10 traced levels.

performed by one operator. Shaping procedures of the two protocols are as follows:

- *Recommended protocol*: The shaping procedure started with a size 10- K-File (Dentsply, Maillefer) followed by PathFile instruments number 013, 016, 019 up to coronal two thirds of the canal (11 mm). This was followed by ProTaper S1 at the same length. After shaping the coronal two thirds of the canal a size 10 K-file scouted the canal up to working length (16 mm) followed by PathFile instruments number 013, 016, 019 and ProTaper S1, S2 and F1 instruments to working length.
- *Modified protocol*: The shaping procedure started with a size 10 K-File used at the coronal two thirds of the canal (11 mm) followed by ProTaper S1 instrument at the same length. Afterwards a size 10 K-File was introduced into the canal up to the working length (16 mm) followed by PathFile instruments number 013, 016, 019 and ProTaper S1,S2 and F1 instruments at the same length.

As S1 and S2 instruments used with brushing motion, a F1 finishing file was used with light pressure and withdrawn from the canal as soon as it reaches the working length for one time.

PathFile rotary instruments were used with a speed and torque-controlled electric motor (X-Smart; Dentsply Maillefer) with a 16:1 contrangle at 300 rpm with the torque of 5 N/cm. Although there is no mention of torque values in the directions for use of the PathFiles and 5 N/cm is the setting described by Berutti et al. [9], recently the manufacturer recommended 0.6 Ncm for PathFiles with the new Wave One motor from Dentsply-Maillefer. Further investigation could be planned to reveal how torque values affect the preparation quality of PathFiles. In all groups, the instrument was coated with EDTA gel (Glyde, Dentsply, Maillefer) as a lubricant, each instrument was cleaned with wet gauze after each use and canals were copiously irrigated with water after the use of each file. All instruments were used for only five canals and shaping procedure was performed by one operator who was experienced in the use of PathFile-ProTaper system and K-Flexofiles. During shaping blocks were covered with dark tissue to not visualize simulated canals. No instrument fractures occurred during the preparation procedures. After preparation all specimens in each group were repositioned in the support and scanned again as described above.

Measurements

Images were evaluated by an experienced endodontist who was not informed about the instrumentation techniques. Pre-instrumentation and post-instrumentation images were superimposed using software by taking the landmarks as reference points. For each image the difference between the canal configuration before and after instrumentation were measured in each one of the 10 traced levels with the help of an Adobe Photoshop Cs5 (Adobe Systems, San Jose, CA) ruler tool (Figure 2). To facilitate the interpretation of the results, mean values of the traced levels in each curvature were recorded and statistically analyzed.

Statistical analyses

NCSS (Number Cruncher Statistical System) 2007&PASS 2008 (Statistical Software Kaysville, Utah, USA) program was used for statistical analyses. One-way Anova was used to test for significant differences between mean values. Tukey HDS test was taken to investigate which means differed from others. Differences were considered statistically significant when $p < 0.05$.

Table I. Mean values of inner and outer cutting effect of all systems.

Zone		Group I Mean ± SD	Group II Mean ± SD	Group III Mean ± SD	*p*
Coronal Curvature	Outer Cutting	0.21 ± 0.1	0.21 ± 0.07	0.12 ± 0.08	0.001**
	Inner Cutting	0.38 ± 0.56	0.41 ± 0.17	0.55 ± 0.3	0.001**
	Inner Cutting	0.27 ± 0.14	0.26 ± 0.14	0.36 ± 0.2	0.001**
Apical Curvature	Outer Cutting	0.13 ± 0.09	0.12 ± 0.08	0.08 ± 0.04	0.004**

*$p < 0.05$; **$p < 0.01$.

Results

Root canal transportation was detected in all groups. Mean cutting values and the statistical difference at two curvatures were shown in Tables I and II, respectively. These results showed that manual instrumentation removed significantly more material from the inner aspect of the coronal and apical curvature when compared with the other groups ($p < 0.01$). There was no statistically significant difference between PathFile-Protaper groups in terms of canal transportation ($p > 0.05$). However, cutting effects of the two group occurred in the inner aspect of the curvatures.

Discussion

The present study evaluated two different PathFile-ProTaper protocols and manual instrumentations in terms of root canal transportation in simulated S-Shaped canals. Numerous studies evaluating the efficacy of instruments have used simulated S-Shaped canals [3,9–12]. With this technique superimposition of the pre-instrumentation and post-instrumentation images of the simulated canals can easily be transferred to computer-based programs to facilitate the evaluation of canal transportation. The experimental design is standardized and reproducible [13]. However, the hardness of the plastic of the resin blocks are different from human root canal walls, but visualization of canal shape before and after preparation allowed information on major preparation characteristics [12]. Peters et al. [14] reported that variations in canal geometry before preparation had more influence on the changes during preparation than the techniques themselves. Considering this, in the present study, simulated root canals were chosen to standardize the root canal morphology and eliminate the variability in the human root canal anatomy.

When comparing different preparation techniques experimentally, it is important to standardize apical preparation diameters. In this study the final apical preparation diameter was size 20 finishing file (F1) for PathFile-Protaper groups and size 20 K-Flexofiles for the manual instrumentation group.

All simulated S-shaped canals were transport at different rates as the result of shaping procedures. This is due to the greater cutting effect performed from the inner aspect of the coronal curvature and apical curvature. These findings are in accordance with previous studies [3,10,13]. It has been reported by several studies that the ProTaper rotary system removed a greater amount of dentine in the middle and coronal parts of the root canal [12,15,16]. Paqué et al. [16] suggested that this may be due to the increased taper of the ProTaper Shaping Files of up to 19%. Bergmans et al. [12] indicated that the bulk of cervical dentine at the mesial side may have forced the Ni-Ti rotary file to distal just below the root canal orifice, causing a movement towards the furcation, especially at the middle-coronal level. They also reported an inner cutting effect at the middle-apical level for ProTaper rotary instruments, which is in accordance with the current results.

Javaheri and Javaheri [5] suggested that ProTaper Ni-Ti rotary instruments indicated a tendency to straighten curved canals. Besides, several studies reported that instrumentation with finishing files, especially with F2 and F3, may have resulted in apical aberrations [3,11,13,16]. In accordance with these views, F2 and F3 finishing files did not include the instrumentation procedure.

Table II. Tukey HSD test.

Zone		Group I–Group II *p*	Group I–Group III *p*	Group II–Group III *p*
Coronal Curvature	Outer cutting	0.965	0.001**	0.001**
	Inner cutting	0.684	0.001**	0.001**
Apical Curvature	Inner cutting	0.985	0.001**	0.001**
	Outer cutting	0.948	0.006**	0.017*

*$p < 0.05$; **$p < 0.01$.

It has been recommended that the ProTaper rotary system should be used in combination with other less tapered more flexible systems to avoid apical transportation in curved canals [5,13,17,18]. Ha and Park [19] reported that creating an acceptable glide path before using ProTaper rotary instruments will reduce the screw-in effect and torque near the apical foramen. In adition, Berutti et al. [20] indicated that glide path formation with Pathfile instruments before using WaveOne NiTi reciprocating file facilitates maintaining the original root canal anatomy by providing lesser alteration of the canal curvature. Pasqualini et al. [21] confirmed the previous studies with a 3D study, reporting that PathFiles have high root canal centering ability and cause less modifications and fewer canal abberations when compared with manual stainless-steel instruments. In accordance with these views it may be suggested that PathFile instruments should be included in the instrumentation procedure of ProTaper rotary instruments in curved canals. It seems that use of these instruments significantly reduce the risk of apical transportation, canal aberrations and instrument failure.

During endodontic therapy, length of an appointment is also important as well as the quality of the treatment. Recently clinicians tend to have better results with using fewer instruments. In addition, it has been suggested that there is a direct proportion between the number of uses and structural deformation of a Ni-Ti rotary instrument [22,23]. While a modified protocol reduces the number of uses for PathFiles it will prevent early structural deformation of the files.

Different from the recommended protocol, in the modified protocol we skip using PathFile instruments at 2/3 working length. However, no difference was observed in terms of canal transportation between the two PathFile-ProTaper groups. This may be due to the cutting effect of the S1 instrument that was used at 2/3 working length in both groups.

The null hypothesis was verified; therefore, it may be suggested that, by the modified protocol, while working safety remains unchanged, the shaping procedure and consequently working time can be shortened with fewer instruments.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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