Evaluation of Root Canal Transportation, Centering Ratio, and Remaining Dentin Thickness Associated with ProTaper Next Instruments with and without Glide Path

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Abstract

Introduction: The purpose of this study was to evaluate and compare the volume of removed dentin, transportation, and centering ability of ProTaper Next (PTN) system with and without glide path preparation by using cone-beam computed tomography (CBCT) imaging. **Methods:** Sixty mesiobuccal canals of mandibular first molars with curvatures of 25°–35° were divided into 3 experimental groups (n = 20) according to the instrumentation technique as follows: group PG/PTN (glide path was created with ProGlider [PG]) and canals were shaped with PTN system), group PF/PTN (glide path was created with PathFile [PF]) and canals were shaped with PTN system), and group PTN (glide path was not performed and canals were shaped with PTN system only). Canals were scanned before and after instrumentation by using CBCT scanner to evaluate root canal transportation and centering ratio at 3, 5, and 7 mm from the apex and volumetric changes. Data were statistically analyzed, and the significance level was set at $P < .05$. **Results:** There was no significant difference among the tested groups regarding the volume of removed dentin and centering ratio ($P > .05$). At 3-mm and 5-mm levels, the PG/PTN group showed a significantly lower mean transportation value among the groups ($P < .05$). However, at 7-mm level, there was no significant difference in canal transportation among the groups ($P > .05$). **Conclusions:** PG/PTN instrumentation method revealed better performance with fewer canal aberrations when compared with instrumentation performed with PF/PTN or PTN only. *(J Endod 2014;40:2053–2056)*

Key Words

Centering ratio, cone-beam computed tomography, glide path, PathFile, ProGlider, ProTaper Next, root canal volume, transportation

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Canal curvature is considered to be the major risk factor for instrument separation that resulted from flexural stresses (1, 2). Instrumentation technique has an important role in avoiding torsional stress that can increase considerably because of exaggerated pressure on the handpiece (3), a wide area of contact between the cutting edge of the instrument and the canal walls (4, 5), or the cross section of the canal is smaller than the size of the nonactive or noncutting tip of the instrument (4, 5). The latter case might result in a taper lock that can be reduced by achieving coronal enlargement and by creating a glide path for instrumentation with nickel-titanium (NiTi) instruments (6, 7). Hence, the diameter of the root canal should be greater or at least the same size as that of the tip of the first rotary instrument used (8).

The PathFile (PF) (Dentsply Maillefer, Ballaigues, Switzerland) NiTi rotary instruments are used for creating an initial glide path mechanically. The system consists of 3 instruments with ISO 13, 16, and 19 tip sizes, a .02 taper, and a square cross section (9). Recently, ProGlider (PG) (Dentsply Maillefer) NiTi rotary instruments were introduced to enhance mechanical glide paths. The PG instrument consists of 1 file glide path with a variable progressive taper. It is manufactured by using M-Wire NiTi alloy to enhance its flexibility and its cyclic fatigue resistance of the files. The PG instrument is available in 21-mm, 25-mm, and 31-mm lengths, and it has a size 16 tip with a taper of .02 mm. It is recommended by the manufacturer to use PG for glide path creation before instrumentation with the ProTaper Next (PTN) (Dentsply Maillefer) system. PTN files exhibit a rectangular cross-section design for superior strength and an exceptional asymmetric rotary motion that improves the file's canal shaping effectiveness according to the manufacturer. They are manufactured by using M-Wire NiTi to enhance its flexibility and enhance the cyclic fatigue resistance of the files (10).

Various methods have been used to evaluate instrumentation of different NiTi rotary systems, including histologic sections, plastic models, serial sectioning, scanning electron microscopy, radiographic comparisons, silicone impressions of instrumented canals, and micro–computed tomography (6, 11–13). Cone-beam computed tomography (CBCT) has also been used to assess root canal instrumentation (13–16). By this method, it is feasible to obtain before and after instrumentation images with no need to cut into the tooth before the process begins (13–15). Furthermore, the quality of the 3-dimensional images acquired by this method is superior to other techniques, which improves its use for geometric analysis of root canal area (13, 14, 16–18).

The aim of this study was to evaluate and compare the volume of removed dentin, the transportation, and the centering ability of PTN system with and without a glide path in the preparation of curved root canals all under the scrutiny of CBCT imaging.

Materials and Methods

Sixty extracted human mandibular first molars with 2 separate mesial canals and apical foramina were selected for this study. Coronal access was made by using an Endo-Access bur (Dentsply Maillefer) in a high-speed handpiece. Size 10 K-files (Dentsply Maillefer) were inserted through the mesiobuccal canals (MB), and the canal curvature was evaluated according to the method of Schneider (19). Only MB canals with curvatures of 25°–35° were included in this study. The distal roots with the respective part of the crown were sectioned at the furcation level by using a low-speed diamond saw (Isomet 1000; Buehler Ltd, Lake Bluff, IL) in conjunction with water, and the distal section was then discarded. The working length was established under ×10 magnification by using a surgical microscope (Global Surgical, St Louis, MO) by inserting size 10 K-file to the root canal terminus and subtracting 1 mm from this measurement (13, 16, 20, 21). The roots were randomly divided into 3 experimental groups (n = 20) according to the instrumentation technique as follows: group PG/PTN (glide path was created with PG and canals were shaped with the PTN system), group PF/PTN (glide path was created with PF and canals were shaped with the PTN system), and group PTN (glide path was not performed and the canals were shaped with PTN system only).

Root Canal Instrumentation

Canals were instrumented according to the manufacturers' instructions for each system. The instruments were operated by using an electric motor (X-Smart; Dentsply Maillefer) with a 16:1 reduction handpiece. Glyde (Dentsply Maillefer) was used as a lubricant during instrumentation. In group PG/PTN, PG (size 16, .02 taper) instrument with a length of 25 mm was used to the working length. Then the root canals were instrumented to the working length by using the PTN system as follows: PTN X1 followed by PTN X2. In group PF/PTN, PF instruments 1 (size 13, .02 taper) and 2 (size 16, .02 taper) with a length of 25 mm were used to the working length. Then the root canals were instrumented to the working length by using the PTN system as follows: PTN X1 followed by PTN X2. In group PTN, first ProTaper Universal SX (Dentsply Maillefer) instrument was advanced into the straight part of the canal. Root canals were then instrumented to the working length by using PTN X1 and PTN X2. The canals were irrigated with 2 mL 5.25% sodium hypochlorite (NaOCl) during instrumentation. Once the instrumentation was completed, 1 mL 17% EDTA (Sigma-Aldrich, Riedel-de Haën, Switzerland) was applied for 3 minutes, followed by final irrigation with 3 mL NaOCl. Each instrument was used to prepare 3 canals, and then the file was discarded.

Image Analysis

The roots were positioned in a custom-made specimen holder in which each root could be placed in the same position before and after instrumentation (22). The roots were aligned perpendicularly to the beam, and they were scanned before and after instrumentation by using the CBCT scanner (Veraviewepocs 3D; J. Morita, Kyoto, Japan) operating at 120 kV and 3–7 mA. The field of view was 8 cm in diameter and 8 cm in height. Slices were 800 × 800 pixels, with a pixel size of 0.125 mm.

CBCT Measurements

Preinstrumentation and postinstrumentation measurements of MB canals were performed by using the OnDemand 3D software (Cybermed Inc, Irvine, CA). The volume of removed dentin was determined in cubic millimeters for each root canal by subtracting the uninstrumented canal volume from the instrumented canal volume (13). Canal transportation and the centering ratio were calculated at 3 cross-section levels that corresponded to 3-mm, 5-mm, and 7-mm distance from the apical end of the root by using the following equations (23):

$$\text{Degree of canal transportation} = (m_1 - m_2) - (d_1 - d_2)$$

$$\text{Canal centering ratio} = (m_1 - m_2)/(d_1 - d_2) \text{ or } (d_1 - d_2)/(m_1 - m_2)$$

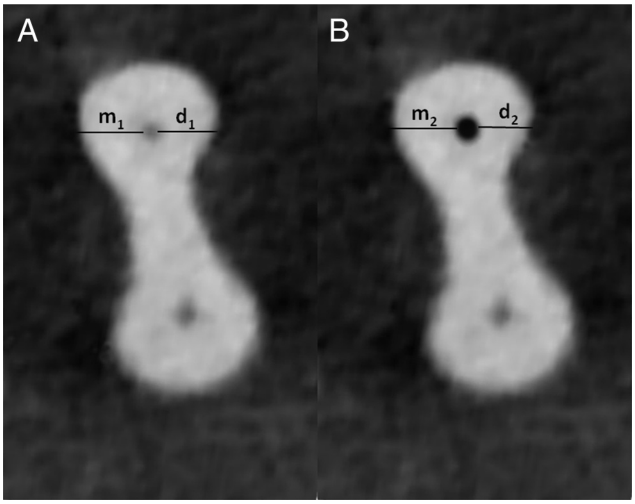

Figure 1. (*A*) Preinstrumentation and (*B*) postinstrumentation CBCT images with markings showing points of measurements used for determination of canal transportation and centering ratio.

where m_1 is the shortest distance from the mesial margin of the root to the mesial margin of the uninstrumented canal, m_2 is the shortest distance from the mesial margin of the root to the mesial margin of the instrumented canal, d_1 is the shortest distance from the distal margin of the root to the distal margin of the uninstrumented canal, and d_2 is the shortest distance from the distal margin of the root to the distal margin of the instrumented canal (Fig. 1*A* and *B*) (13, 23, 24).

Statistical Analysis

A statistical analysis (SPSS 15.0; SPSS Inc, Chicago, IL) of the canal transportation and centering ratio values was performed by using one-way analysis of variance. Multiple comparisons were made by using the Tukey test. Volume changes data showed a nonparametric distribution. Consequently, the Kruskal-Wallis H test was used to compare among the groups. Statistical significance level was set at $P < .05$.

Results

Volume of Removed Dentin

Table 1 shows the mean and standard deviation values of the volume of removed dentin for each group. The PG/PTN group showed the lowest mean volume of removed dentin (2.91 ± 1.71 mm^3), followed by PF/PTN group (2.97 ± 1.15 mm^3). The PTN group without glide path recorded the highest volume of removed dentin (3.03 ± 1.78 mm^3); however, there was no significant difference among the tested groups regarding the volume of removed dentin ($P > .05$).

Canal Transportation and Centering Ratio

Table 2 shows the mean and standard deviation values of the canal transportation and the centering ratio at the 3 studied levels for each

TABLE 1. Mean ± Standard Deviation of Volume of Removed Dentin (mm^3) for Tested Groups and Statistical Analysis

Group	Mean ± SD	*P* value
PG/PTN	2.91 ± 1.71	
PF/PTN	2.97 ± 1.15	.773
PTN	3.03 ± 1.78	

SD, standard deviation.

TABLE 2. Mean ± Standard Deviation of Transportation (mm), Centering Ratio Values for Tested Groups, and Statistical Analysis

Level	Assessment	PG/PTN	PF/PTN	PTN	*P* value
3 mm	Transportation	$0.05^b \pm 0.02$	$0.07^a \pm 0.03$	$0.10^a \pm 0.05$	.004
	Centering ratio	0.55 ± 0.12	0.53 ± 0.18	0.46 ± 0.14	.116
5 mm	Transportation	$0.07^b \pm 0.03$	$0.09^a \pm 0.05$	$0.14^a \pm 0.07$	.001
	Centering ratio	0.52 ± 0.16	0.49 ± 0.19	0.42 ± 0.15	.193
7 mm	Transportation	0.15 ± 0.07	0.17 ± 0.08	0.19 ± 0.09	.251
	Centering ratio	0.39 ± 0.11	0.37 ± 0.12	0.35 ± 0.14	.583

Mean values represented with different superscript letters are significantly different according to Tukey test ($P < .05$).

group. At 7-mm level, there was no significant difference in canal transportation among the groups ($P > .05$); however, at 3-mm and 5-mm levels, the PG/PTN group showed a significantly lower mean transportation value among the groups ($P < .05$). There was no significant difference in canal transportation values between PF/PTN and PTN groups ($P > .05$). The data of the centering ratio showed that there was no significant difference among the tested groups after instrumentation ($P > .05$).

Discussion

Better endodontic outcomes are achieved when preserving the original canal shape by using less invasive methods (25). The present study aimed to evaluate the shaping performance of the PTN system both with and without a glide path by using the new PG and PF glide path systems in the preparation of curved root canals. It has been suggested that the evaluation of changes in canal shape after instrumentation is a reliable process to assess the ability of a shaping technique to preserve the original canal shape (26, 27). In the present study, the CBCT tool was used to evaluate the shaping performance of the tested groups. The CBCT imaging method is a noninvasive and a relevant process for the analysis of canal geometry and for the analysis of shaping techniques. It is feasible to evaluate the anatomic structure of the root canal before and after instrumentation by using CBCT (13, 17, 28).

Curved canals have been commonly used as specimens in research studies because these canals present with a greater challenge to instrumentation (29). Thus, evaluation of the performance of different instrument systems has been correlated to their ability for shaping curved canals and their ability to maintain the original anatomy of the canal to verify its curvatures (26, 27, 29). In the present study, 3 levels were chosen: 3, 5, and 7 mm. These measurements represent the apical, middle, and coronal thirds of root canals where curvatures with high vulnerability to iatrogenic mishaps typically exist. The crowns corresponding to the mesial roots were kept intact to reproduce clinical situations where the interference of cervical dentin could produce unwanted directional tension or resistance during canal instrumentation (13).

Performing coronal enlargement and preflaring have been verified to be crucial procedures to allow safer use of NiTi rotary instrumentation in curved canals because they provide the files a more direct path to the apical end of the canal, while lessening any coronal resistance or redirection of the files apically (8, 30). In the present study, regarding the volume of removed dentin, there was no significant difference among the tested groups. However, PTN without a glide path showed a higher mean volume of removed dentin compared with the other tested groups. It has been reported that PTN X2 was associated with the highest torque, and particular care should be taken when using X2 because this file may show considerable contact with the canal walls (31). On the other hand, PTN instruments demonstrated less dentin removal when used after a previous glide path with both PG and PF systems. Although the PG/PTN instrumentation technique showed less amount of removed dentin than PF/PTN, there was no significant difference between the PG/PTN and PF/PTN techniques. This could be attributed to the manufacturing process of PG system including the M-Wire technology that provides greater flexibility and greater resistance to cyclic fatigue than those instruments made of regular superelastic wire (32).

The creation of a glide path of the canal enhances the performance of PTN instruments. It has been reported that glide path preparation allows the preservation of a pathway to the full working length, thus avoiding excessive binding in the canal (28). In addition, preflaring tends to reduce procedural errors such as transportation and ledge formation (26). In the present study at 3-mm and 5-mm levels, the PG/PTN group showed significantly lower mean transportation values among the groups. The finding of the present study could be attributed to the effect of creating a glide path by using the PG system that may have resulted in less stress on PTN during instrumentation. This might be attributed to the innovative M-Wire NiTi technology for both PTN and PG systems. It is suggested by the manufacturer that a PG instrument follows the use of a size 10 K-file in the canal. On the other hand, at the 7-mm level, there was no significant difference in canal transportation among the tested groups. It has been concluded that apical transportation greater than 300 μm may have a negative effect on the apical seal during obturation (33). In the present study, none of the tested groups exceeded this limit.

Regarding the results of the centering ratio, there was no significant difference in the performance of PTN with PF and PG systems. It has been reported that PF NiTi rotary instruments maintain the original canal anatomy, cause less canal aberrations (34), and produce less postoperative pain and faster symptom relief because the number of files reaching the apical foramen and the time of apical instrumentation are considerably decreased when compared with manual stainless steel instrumentation (35). The use of PG and PF glide path systems resulted in a more centered canal with greater remaining dentin thickness. In the present study, it was observed that fewer "pecking" motions were required to attain the full working length with PTN instruments when a glide path had been created previously. It could be assumed that this would decrease the possibility of misdirected instrumentation and subsequent root canal transportation (6, 26).

In conclusion, the use of a small size hand K-file that is followed by a more flexible and less tapered PG glide path system might preserve the root canal shape and thus enhance the instrumentation with PTN files. The PG/PTN instrumentation method revealed better performance with fewer canal aberrations when compared with instrumentation performed with PF/PTN or PTN only.

Acknowledgments

The authors deny any conflicts of interest related to this study.

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