Comparative Assessment for the Effect of Dia-X Files Versus ProTaper Next on Canal Angulation Changes and Degree of Apical Transportation: An In vitro Cone-Beam CT Study

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Abstract

The outstanding development of NiTi rotary filing systems, has left a great effect on endodontic practicing, which may be mainly related to the superior characteristics of the material itself as well as the continuous innovations regarding its manufacturing process and heat treatments. The aim of this present study, was to compare and evaluate the shaping performance of two rotary Nickel Titanium files, namely; ProTaper Next, Dia-X Files in curved root canal preparation, regarding the extension of apical transportation and amount of canal angulation changes.

Apical transportation as well as degree of canal curvature were measured using the Cone Beam Computed Tomographic scanning, then all the data were statistically analyzed by the aid of Chi-square test and paired Student's t test.

Within the limited conditions of the present study, there was no significant difference in apical root canal transportation between both systems. Moreover, both systems tend to retain the original canal curvatures within the same degree.

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Introduction

Treatment of endodontically treated teeth in a successful way, considers mainly a thorough canal preparation, accurate obturation and perfect microbial control. These includes both mechanical and biological objectives of root canal treatment. Upon discussing the mechanical objectives, we concentrate mainly on carving away the restrictive dentin and sculpting a preparation which is thoroughly cleaned and designed to receive an acceptable three-dimensional obturation. Most of the recent researches suggest that Nickel Titanium files are functioning in the best way and may cause less transportation and deviation in the canal anatomy when they are used in a reaming motion or as being used recently in a rotary motion with much more promising results than with normal stainless-steel files[1-4]. That is mainly the cause of the great evolution that occurred in the manufacturing of mechanized rotary instruments using specifically designed Nickel Titanium files for root canal preparation due to their high efficacy in canal shaping and canal curvature maintenance, as well as keeping the apical foramen away from any unneeded transportations[5,6]. However, such Nickel Titanium instruments are not behaving the same way throughout their usage in canal preparations, this may be partially related to the clearly apparent anatomical variations between different teeth and root canal anatomies[7-9]. Also, the recent innovations which includes both of the material designs and constructions of Nickel Titanium files[10-15]. From those significant modifications of Nickel Titanium rotary filing systems was the outstanding innovation of the M-Wire Nickel Titanium alloys (Dentsply Tulsa Dental Specialties) with its unique ability of tracking the canal curvatures through its magic snake-like swaging movement and special offset rotation center as well as their enhanced fatigue resistance and superior material flexibility[16-20].

In the present study, we aimed to evaluate the degree of apical transportation and canal angulation changes using the ProTaper Next (Dentsply; Maillefer, Ballaigues, Switzerland), and the Dia-X Files (DiaDent Group International. Burnaby, Canada) during root canal preparation procedures.

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Materials and methods

Selection of samples

A total of forty-eight (48) freshly extracted human mandibular permanent second premolars with single roots and with a slightly curved root canals, were selected free from any obvious defects or abnormal morphology and were collected to be used in the current study. All the root canals were being checked for a completely formed roots with mature apices and their patency were confirmed using # 10 or # 15K-files. Then the angles of curvature were determined using Schneider's technique [21]. Finally, all the canals were instrumented, so that a total of forty-eight root canals were used for this study.

Preparation of the samples

All the teeth were thoroughly washed under pure running water and then were air-dried, the selected samples were then cleaned and scaled using ultrasonic scaler, and then polished with polishing paste. The crowns of all the specimens were cut exactly at their cervical edge using a safe- sided disc which is mounted on a high-speed handpiece, all of that were done mainly to exclude any unneeded variations during the preparation which might be due to some differences in the access opening procedures. An appropriately sized barbed broaches were then used to remove the pulp from the root canal systems. After that, the working length of each root canal was adjusted at 1mm short from the anatomical tooth length. Then all the apices were sealed using green stick compound to prevent the loss of the irrigating solutions through the apical foramen. Teeth were then finally stored in 1% normal saline till the start of the working procedures.

Preparation of sample moulds

Plastic boxes were used as moulds for designing transparent acrylic boxes of 2 cm length, 2 cm width and 2.5 cm height. A transparent acrylic resin was mixed and prepared according to the manufacturer's instructions then poured into the mould. All the teeth were embedded in the moulds where their long axis being parallel to the mould until reaching the their cemento-enamel junction. An adequate time was given for the complete setting of the acrylic resin. Moulds were then trimmed and polished. All the boxes were then labeled and enumerated for later evaluation. A prefabricated wax model that simulates the human mandible was then used to place the acrylic boxes inside to be accurately positioned inside the CBCT scanning machine for later scanning procedures. That was mainly done to assure accurate teeth placement inside the machine before and after the canal preparation procedures in the exact position.

Grouping

Teeth were divided into two main divisions, consisting of twenty-four (24) teeth each. In Division I: Root canals were prepared with the Protaper Next filing system starting with the glide path files, P1 and P2 and then followed by shaping files respectively, X1: 20/0.04, then going through X2: 25/0.06 and ending with X3: 30/0.06 reaching the full canal working length. On the other hand, and concerning Division II: Root canals were prepared with the Dia-X File system starting by file DX (coronal shaping) till reaching middle third of the canal depth, then followed by D1 and D2 Shaping files and finally with D3 Finishing file by which it reaches the full working canal length. All samples were prepared using an endodontic rotary contra-angle motor, namely, X-Smart (Dentsply, Sirona, Canada) under a speed of 300 rpm and a torque of 2.4 Ncm. that is mainly designed for most of the rotary filing systems. All canals were also instrumented using Crown-down preparation technique and preparation steps that follows the manufacturer instructions specific for each system. Copious irrigation was done by the aid of a 27Gauge side-vented irrigating needle (NaviTip; Ultradent, South Jordan, UT) using 5.25% of sodium hypochlorite irrigating solution (NaOCl) followed by a final flush of 17% ethylenediaminetetraacetic acid (EDTA).

Computed tomographic evaluation

Cone-Beam computed tomographic radiographs were taken for all teeth, including both pre- instrumentation and post instrumentation scanned images, by the aid of Galileos machine, were the scanning parameters are 98Kv and exposure time of 14seconds. The field of view was 12 X 15cm and the voxel's size was 0.125 mm (Sirona Dental Systems; GmbH, Bensheim, Germany). Finally, all the data were then collected and then analysis was done by the software (sidexis 4). Finally, each image was coded and inserted in a separate file for later

identification and evaluation.

A) Measurements of apical transportation: By using the soft-ware of the CBCT system, a line was drawn 2mm from the radiographic apex perpendicular to the long axis of the canal in the apical third. On this line, the mesial and distal dentin thickness in the buccal view were measured. The same measurements recorded from the pre-instrumented images were identically repeated and compared to that taken from the post-instrumented one. Degree of transportation (X1-X2)- (Y1-Y2), where X1= Pre-instrumented mesial dentin thickness, X2= Pre-instrumented distal dentin thickness, Y1= Post-instrumented mesial dentin thickness and Y2=Post- instrumented distal dentin thickness Figure 1.

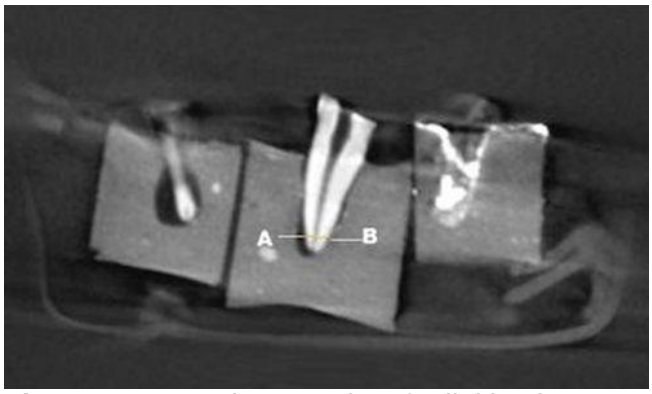

Figure 1. A Photograph of digitized CBCT scanned image showing measurements of apical transportation: (A) Represents mesial dentin thickness. (B) Represents distal dentin thickness.

B) Measurements of canal curvatures: According to Schneider's technique, pre-and post-instrumented canal angulations were measured. By the aid of the CBCT advanced software system, a vertical angulation of every canal in each image was determined by drawing a straight-line tangent to the interior wall of the canal in the coronal one third of the root. Another straight line was drawn tangent to the interior wall of the canal in the apical 2-3 mm. The intersection of these two lines forms an interior angle whose value was presented in the corresponding location in the measurement box of the imaging system. The values obtained from the pre-instrumented measurements were compared to those obtained from post-instrumented measurements, then the percentage changes were calculated Figure 2.

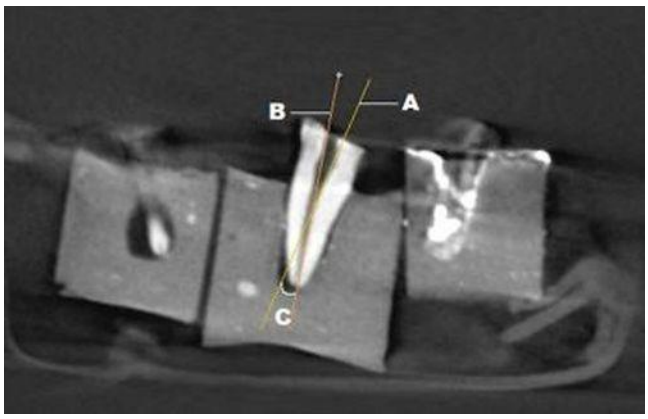

Figure 2. A Photograph of digitized CBCT scanned image showing measurements of canal curvature: (A) Straight line tangent to the interior wall of the canal in the coronal third of the root. (B) Straight line tangent to interior wall of the canal in the apical third of the root. (C) Interior angle resulting from intersection of the two lines.

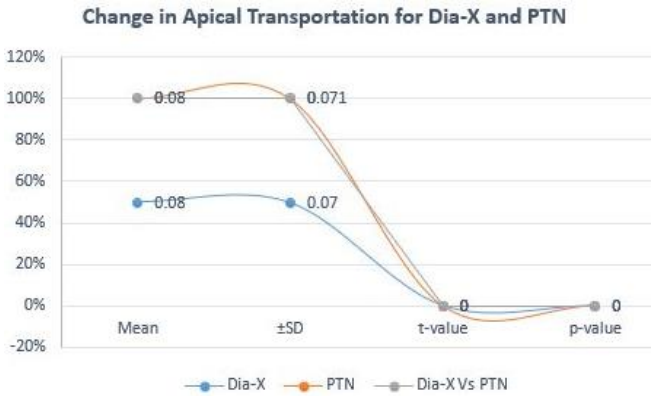

Figure 3. A graph showing the changes in apical transportation for Dia-X and PTN systems.

Results

The collected data were analyzed statistically using Chi-square test as well as paired Student's t-test. After that, the data were tabulated to be finally illustrated in graphs that shows the degree of changes in both apical transportation and in canal curvatures.

1. Changes in apical transportation: Table 1,2

The tables show the mean and standard deviation of the canals instrumented with Dia-X File system to be 0.0800 + 0.0700 and those done with the PTN systems are found to be 0.0800 + 0.0710. This indicates no significant difference between both groups (P=1.000).

Moreover, there was no significant difference also between those which tend to transport to the mesial or the distal side (P=0.9115) Figure 3.

	Mean	±SD	t-value	p-value
Dia-X	0.0800	0.0700		
PTN	0.0800	0.0710		
Dia-X Vs PTN			0.00	1.0000 ns

Table 1. The mean, standard deviation and calculated P-value of transportation of Dia-X and PTN systems. ****P<0.0001; ***P<0.001; P<0.01; P<0.05; ns=not significant (P>0.05)

	Dia-X %	PTN %	Total %
None	17%	17%	17%
Mesial	17%	33%	25%
Distal	50%	33%	42%
Both	17%	17%	17%
Total	100%	100%	100%

Chi-square = 0.53 P = 0.9115 ns

Table 2. The percentage of transportation and calculated P-value for Dia-X and PTN systems in the mesial direction, distal direction and both directions.

		Mean	± SD	Mean Difference	Mean % Change	T-value	P-value
Dia-X	Pre-instrumentation	24.33	5.39	-0.67	-2.3%	1.58	0.1747 ns
	Post-instrumentation	23.67	4.84				
PTN	Pre-instrumentation	20.67	5.01	-1.17	-4.9%	1.40	0.2204 ns
	Post-instrumentation	19.50	4.46				

ns = not significant

Table 3. The mean, standard deviation, percent of changes and calculated P-value of pre and post canal curvatures for Dia-X and PTN systems.

	Dia-X Vs PTN	
	Pre-instrumentation	Post-instrumentation
T- value	1.22	1.55
P- value	0.2502 ns	0.1522 ns

ns = not significant

Table 4. The calculated P-value of pre and post canal curvatures for Dia-X versus PTN systems.

2. Changes in canal curvatures: Table 3,4

There were no significant difference between the mean as well as the standard deviation of the pre-instrumented 24.33 + 5.39 and post-instrumented 23.67+4.84 canal curvature using Dia-X File system (P=0.1747).Once more, there were no Significant difference between mean and standard deviation of pre-instrumented 20.67 + 5.01 as well as post-instrumented 19.50 + 4.46 canal curvatures upon using the PTN system (P=0.2204). Both Dia-X File and PTN groups show no Significant difference when compared to each other in either the pre-instrumented (P=0.2502) or the post-instrumented (P=0.1522) canal angulation changes Figure 4.

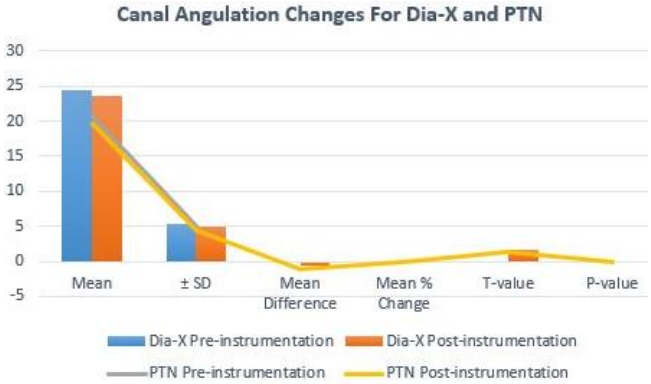

Figure 4. A graph showing the angulation changes for Dia-X and PTN systems.

Discussion

Endodontic preparation begins as soon as we start using our cutting instrument inside the canal, and it ends up through reaching our three-dimensional obturating procedures. However, it depends in a great measure on how we precisely attain our first line of treatment in such initial steps, where a lot of different theories and opinions had been eventually mentioned and discussed to reach the most perfect and accurate methods concerning root canal preparation to be ready for receiving an ideal obturation as well [22].

It is well known that the evolution happened with the start of using NiTi filing systems, has a great effect on endodontic practicing. This might be related to the superior characteristics of the material, including mainly its superior elastic manner that permits preserving the canal curvatures as well as retaining its original shape and avoiding any unneeded cutting of the canal space. Moreover, Ni-Ti rotary instruments have also sharply reduced many clinical mishaps, such as blocks, ledges, transportations and perforations. If used

correctly, they can be of a great help in facilitating root canal preparation procedures. This was actually much more modified by the manufacturing of the most super elastic heat-treated version of nickel titanium, namely; the M2 Wire that affords a swaging ability inside the root canals which in turn preserve its original shape in a perfect way[23,24].

This present study was conducted to evaluate and compare the shaping ability of two types of rotary Ni-Ti files; namely, ProTaper Next (PTN) and Dia-X Rotary File (Dia-X Files) systems, in curved root canal preparation. Mandibular second permanent premolars with slightly curved canals were selected for this study. Both types of those rotary filing systems were used for canal instrumentation by applying the manufacturer instructions specific for each system and using the crown-down pressurless technique. Compared to the step-back technique, Morgan and Montgomery [25], found that using the crown-down technique during canal preparation procedures effectively results in preserving the terminal shape of the canal from any unneeded widening. Another invitro study found also that there is a definitive decrease in debris extrusion from the canal apex toward the periapical area upon using such technique [26].

ProTaper Next system consists of five main instrument sizes: Two glide path files, namely P1 and P2 and two shaping files, namely, X, X2 and finally X3 whenever needed. There are also three more optional files that are used mainly in large canals or those with immature apices or larger apical foramina than normal.

On the other hand, the Dia-X File system consists mainly of five backed files, starting by DX file for coronal approach which reaches about one third to half of the canal depth and then moving through file number D1 and D2 were the apex of the canal is already reached and ending with D3 finishing file by which most of the cases will be finished. However, in some other cases, treatment might proceed with files number D4 or D5 in case more finishing is needed or according to the variations in the width of the apical foramen in different situations.

Both systems worked in a speed range of 250-350 rpm using a slow gentle in and out movement. Sodium hypochlorite irrigation was used in conjunction with 17% EDTA lubricant that were placed into the canal using a gauge 27 side-vented irrigating needle. An X-Smart Plus contra-angled motor was selected to be used in our study. This motor was specially manufactured for the use of rotary NiTi files in a speed of 300 rpm and under a torque of 2.4 Ncm. A fingertip of one touch ON/OFF switch is present, having the advantage of a feedback circuit which keeps rotation at a constant speed even when the load on the motor handpiece changes. The hand piece is also supplied with an auto-stop mechanism that permits rotation in the forward direction, once about 75% of the selected torque limit is reached, any more load will direct the hand piece to a force stop.

In the present study, method of radiographic evaluation was done depending mainly on the use of Cone-Beam Computed Tomography which proved its efficiency regarding measurements of very limited spaces and minimal sizes[27-32]. The machine used for this purpose in the current study is “Galileos machine’, which attains a high quality of imaging and superior scanning parameters as well.

As regards the degree of apical transportation in this study, a superior performance of both rotary NiTi files was noticed with no actual tendency to transport the canals towards the mesial or the distal sides. Considering changes in canal curvatures, both systems were able to retain the canal curvature with no significant difference between either of them. This may be due to the super-elastic properties of the NiTi files that retain them highly flexible. This is added to the low modulus of elasticity and wide range of elastic deformation which aids in maintaining the original canal shape and curvature throughout the whole preparation steps.

Conclusions

Under the conditions of this study, there were no significant difference in apical canal transportation between the Dia-X File system and the PTN system. On the other hand, both systems tend to retain the canal curvature with the same degree. Other investigations may be also recommended under much more difficult conditions like complicated canal anatomies and higher degrees of curvatures.

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Declaration of Interest

There was no conflict of interest declared in the present study.

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