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Computed Tomographic Evaluation of Shaping Ability for FKG Dentaire and ProTaper Next Files on Preservation of Canal Width and Degree of Taper

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Abstract **Objectives:** This current study was performed to evaluate the ability of two rotary filing systems; namely, FKG Dentaire NiTi files (La Chaux-de-Fonds,Switzerland) and ProTaper Next NiTi files (Dentsply Maillefer, Ballaigues, Switzerland) in preservation of canal width and degree of taper after instrumentation in root canal system. **Materials and Methods:** A total of sixty-four freshly extracted single-rooted first mandibular permanent human premolar teeth with single canals were selected. The teeth were then decoronated and the canals were instrumented. Teeth were then divided into two main groups, consisting of thirty-two each. Root canals were prepared using the FKG Dentaire system in the first group and the PTN (ProTaper Next) system in the second group. Degree of canal width changes and change in canal taper were measured by using the Cone-Beam Computed Tomography (CBCT) before and after root canal instrumentation. Finally, all data were collected and statistically analyzed by the aid of the paired Student's t and Chi-square test. **Results:** At the minimal width changes measurements, 1mm from the apex, it was found that no significant difference exists between the mean and standard deviation of pre-instrumented and post-instrumented groups using FKG system, (P=0.0756). However, a significant difference exists between the mean and standard deviation of pre- and post-instrumented groups using the PTN system, (P=0.0117). On the other hand, at the maximum width changes measurements, 7mm from the apex, it was found that a significant difference exists between the mean and standard deviation of pre- and post-instrumented groups using FKG system, (P=0.0015). While a highly significant difference exists between the mean and standard deviation of pre- and post-instrumented groups using PTN system, (P=0.0005). **Conclusion:** Under certain conditions of this study, FKG system appears to remove lesser dentin with more tendency to preserve the canal taper and decrease any unneeded enlargement.

Keywords: *CBCT, canal taper, canal width, FKG, protaper next*

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1. Introduction

The evolution of rotary instruments using specially designed Ni-Ti files for root canal treatment were designed due to their unique speed characteristics as well as their efficacy in canal shaping and maintaining canal curvature, besides maintaining apical foramen away from any unneeded transportation [1,2]. However, those Ni-Ti instruments will never behave the same way during root canal preparations, this might be related to the significant anatomical variations between different teeth [3,4] as well as recent innovations concerning material constructions and designs of NiTi files [5-10]. The most recent significant modification of NiTi rotary filing systems was the innovation of the M-Wire NiTi alloy (Dentsply Tulsa Dental Specialties) with its unique ability of tracking canal curvatures through its snake-like swaggering movement as well as its specific offset rotation center and their enhanced fatigue resistance and superior flexibility [11-16].

It is well known that successful endodontic treatment includes a thorough root canal preparation, microbial control and obturation. The major role of mechanical objective for root canal treatment is to carve away restrictive dentin and sculpt a preparation that is thoroughly cleaned and prepared to receive a three-dimensional obturation. All of the recent researches suggest that Ni-Ti files may function best and cause less transportation and deviation in anatomy when used in a reaming or rotary motion that gives better and more significant successful results than normal stainless-steel files [17,18,19,20]. That was typically approved upon using recent ways of evaluation as computed tomography, due to its high accuracy of measuring any differences

regarding canal width changes or apical transportations [21].

In the current study, we aimed to compare and evaluate the degree canal width change and the preservation of the normal canal taper using the FKG Dentaire rotary NiTi files (La Chaux-de-Fonds, Switzerland) and ProTaper Next NiTi files (Dentsply Maillefer, Ballaigues, Switzerland) which is known to be the successor of the ProTaper Universal system (Dentsply Maillefer), during the preparation of curved canals.

2. Materials and Methods

2.1. Preparation of the specimens

A total of sixty-four freshly extracted first mandibular permanent human premolar teeth with single canals that are free from any obvious defects or abnormal morphology are collected to be used in this study. The crowns of all the teeth were removed at the level of the cervical edge by the aid of safe-sided disc mounted on a high-speed handpiece under Copious flow of water. That was done to exclude any variation in instrumentation that might happened by differences in access opening preparations. Teeth were then divided into two main groups, consisting of thirty-two teeth each. Root canals were prepared using the FKG system in the first group and the PTN (ProTaper Next) system in the second group. Root canals were checked for completely formed roots with mature apices, patency was confirmed with # 10 or # 15K-files. Teeth were then thoroughly washed under running water and air- dried, the selected samples were then scaled using ultrasonic scaler, and polished with a polishing paste. The pulp was then removed from the canals using appropriate size barbed broaches. After that, the working length of each canal was adjusted 1mm shorter from the anatomical root length. Apices were then sealed with a small amount of green stick compound to prevent loss of solutions through the apical foramen during irrigation. Teeth were then stored in 0.9% normal saline till the time of preparation and investigation. On the other hand, acrylic boxes were fabricated using transparent acrylic resin that was mixed and prepared then poured into moulds with dimensions of 1.5cm length, 1.5cm width and 2cm height. Each tooth was then embedded with its long axis parallel to the mould until the cemento-enamel junction is reached. Sufficient time was given to complete setting. Then the boxes were trimmed and polished. All of that was done to assure accurate placement of the roots before and after root canal preparation in the same position. These boxes were enumerated and labeled for later radiographic evaluation. The boxes were then placed in another prefabricated wax model that simulates the natural mandible to be positioned inside the CBCT scanning machine and be ready for radiographic scanning.

2.2. Grouping and Instrumentation

Teeth were then divided into two main groups. Concerning the first group, root canals were prepared with FKG system till file number R3: 30/04 FKG using Rooters S Cordless endodontic motorized handpiece and contra-angle (La Chaux-de-Fonds, Switzerland) designed specifically for these files with a speed of 1000 rpm and under a torque of 1 Ncm. On the other hand, the second group were prepared with Protaper Next system till file number X3: 30/0.06 taper using X-Smart endodontic rotary contra-angle motor (Dentsply, Sirona, Canada) designed for rotary files with a speed of 300 rpm and under a torque of 2.5 Ncm. All the canals were prepared using the Crown-down pressurless technique and the steps of preparation were following the manufacturer instructions for each system

2.3. Radiographic Evaluation

Regarding the computed radiographic evaluation, Pre and Post instrumentation scanned images were taken for all teeth using Cone-Beam Computed Tomography, CBCT Figure 1. This was done using Galileos machine (Sirona Dental Systems GmbH, Bensheim, Germany), the scan parameters were 98 Kv, mA: 3-6 with exposure 14 sec., field of view was 15 X 12 cm and voxel size was 0.125mm. All data were reconstructed in slices of 1mm intervals. analysis was done in the proprietary software (sidexis4). Finally, each image was separately filed and coded for the ease of identification.

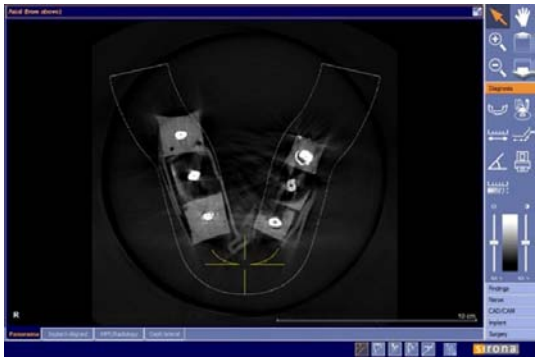


Figure 1. Photograph showing the specimens arranged and scanned by Computed Tomographic machine (CBCT)

Measurements of canal width changes: Differences between pre-instrumented and post-instrumented root canal width were recorded at levels 1, 3, 5 and 7mm distances from the root apex by the aid of the CBCT software program and calculated in mm^2 Figure 2, Figure 3.

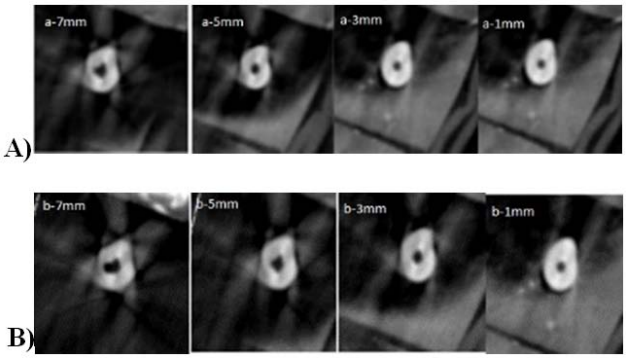


Figure 2. Photographs of digitized CBCT scanned images showing specimens before (A) and after (B) instrumentation with PTN filing system at four levels of preparation, 7, 5, 3, and 1mm from the apex respectively

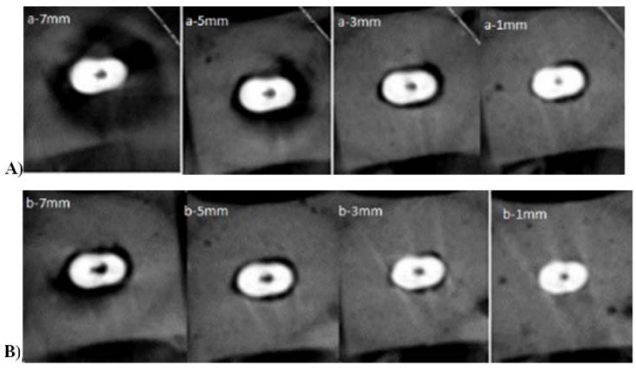


Figure 3. Photographs of digitized CBCT scanned images showing specimens before (A) and after (B) instrumentation with FKG filing system at four levels of preparation, 7, 5, 3, and 1mm from the apex respectively

3. Results

All the data were collected and statistically analyzed by the aid of the paired Student's t-test and Chi-square test. These analyzed data were then tabulated and illustrated graphically to clear the degree of changes in canal taper and width changes Figure 4. Canal width changes at four levels (1, 3, 5 and 7mm distances from the root apex) were calculated.

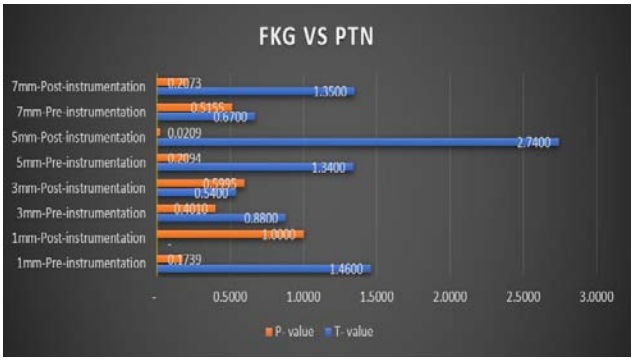


Figure 4. Graph showing the calculated P-value and T-value of pre-instrumented and post-instrumented canal width for FKG versus PTN systems at levels 1, 3, 5, and 7mm from the apex

3.1 At 1mm from the Apex Table 1, Table 5

No significant difference exists between the mean and standard deviation of pre-instrumented 0.300 ± 0.063 and post-instrumented 0.350 ± 0.055 canals using FKG system (P=0.0756). A significant difference exists between the mean and standard deviation of pre-instrumented 0.250 ± 0.055 and post-instrumented 0.350 ± 0.055 canals using the PTN system (P=0.0117). No significant difference exists between both FKG and PTN groups in either pre-instrumented (P=0.1739) or post-instrumented (P=1.0000) values.

3.2. At 3mm from the Apex Table 2, Table 5

No significant difference exists between the mean and standard deviation of pre-instrumented 0.350 ± 0.055 and post-instrumented 0.400 ± 0.063 canals using FKG system (P=0.0756). A significant difference exists between the mean and standard deviation of pre-instrumented 0.317 ± 0.075 and post-instrumented 0.417 ± 0.041 canals using the PTN system (P=0.0117). No significant difference exists between both FKG and PTN groups in either pre-instrumented (P=0.4010) or post-instrumented (P=0.5995) values.

3.3. At 5mm from the Apex Table 3, Table 5

A significant difference exists between the mean and standard deviation of pre-instrumented 0.383 ± 0.041 and post-instrumented 0.500 ± 0.063 canals using FKG system (P=0.0019). A significant difference exists between the mean and standard deviation of pre-instrumented 0.433 ± 0.082 and post-instrumented 0.600 ± 0.063 canals using FKG system (P=0.0199). No significant difference exists between both FKG and PTN groups in pre-instrumented specimens (P=0.2094). However, A significant difference exists between both FKG and PTN in the post-instrumented specimens (P=0.0.0209).

3.4. At 7mm from the Apex Table 4, Table 5

A significant difference exists between the mean and standard deviation of pre-instrumented 0.500 ± 0.089 and post-instrumented 0.633 ± 0.082 canals using FKG system (P=0.0015). A highly significant difference exists between the mean and standard deviation of pre-instrumented 0.533 ± 0.082 and post-instrumented 0.700 ± 0.089 canals using PTN system (P=0.0005). No significant difference exists between both FKG and PTN groups in either pre-instrumented (P=0.5155) or post-instrumented (P=0.2073) values.

Table 1. The mean, standard deviation, percent of change and calculated P-value of pre and post canal width 1 mm from the apex for FKG and PTN systems and the calculated P-value of pre and post canal width for FKG versus PTN systems

		Mean	± SD	Mean Difference	Mean % Change	T-value	P-value
FKG	Pre-instrumentation	0.300	0.063	0.050	19.4%	2.24	0.0756 ns
	Post-instrumentation	0.350	0.055				
PTN	Pre-instrumentation	0.250	0.055	0.100	44.4%	3.87	0.0117
	Post-instrumentation	0.350	0.055				

ns = not significant (P>0.05).

Table 2. The mean, standard deviation, percent of change and calculated P-value of pre and post canal width 3 mm from the apex for FKG and PTN systems

		Mean	± SD	Mean Difference	Mean % Change	T-value	P-value
FKG	Pre-instrumentation	0.350	0.055	0.050	15.3%	2.24	0.0756 ns
	Post-instrumentation	0.400	0.063				
PTN	Pre-instrumentation	0.317	0.075	0.100	37.5%	3.87	0.0117
	Post-instrumentation	0.417	0.041				

ns =not significant.

Table 3. The mean, standard deviation, percent of change and calculated P-value of pre and post canal width 5 mm from the apex for FKG and PTN systems and the calculated P-value of pre and post canal width for FKG versus PTN systems

		Mean	± SD	Mean Difference	Mean % Change	T-value	P-value
FKG	Pre-instrumentation	0.383	0.041	0.117	30.6%	7.00	0.0019
	Post-instrumentation	0.500	0.063				
PTN	Pre-instrumentation	0.433	0.082	0.167	44.2%	3.37	0.0199
	Post-instrumentation	0.600	0.063				

ns =not significant.

Table 4. The mean, standard deviation, percent of change and calculated P-value of pre and post canal width 7 mm from the apex for FKG and PTN systems and the calculated P-value of pre and post canal width for FKG versus PTN systems

		Mean	± SD	Mean Difference	Mean % Change	T-value	P-value
FKG	Pre-instrumentation	0.500	0.089	0.133	28.1%	6.32	0.0015
	Post-instrumentation	0.633	0.082				
PTN	Pre-instrumentation	0.533	0.082	0.167	32.2%	7.91	0.0005
	Post-instrumentation	0.700	0.089				

ns =not significant.

Table 5. The calculated P-value of pre and post canal width for FKG versus PTN systems at 1, 3, 5, and 7mm from the apex

Distance From the Apex	FKG versus PTN			
	Pre-instrumentation		Post-instrumentation	
	T- value	P- value	T- value	P- value
1 mm	1.4600	0.1739	0.0000	1.0000
3 mm	0.8800	0.4010	0.5400	0.5995
5 mm	1.3400	0.2094	2.7400	0.0209
7 mm	0.6700	0.5155	1.3500	0.2073

4. Discussion

It is so familiar to all endodontic specialists now, how the use of nickel titanium files has added a lot to the practice of endodontics due to the super elasticity of this alloy that sustain deformation and retain permanent shape of the canal. This accordingly leads to more flexible endodontic files which are much more able to conform to canal curvature, resist fracture and wear less than stainless steel files. Ni-Ti rotary files have clearly reduced a lot of previously repeated clinical mishaps, as ledges, blocks, perforations and apical transportations. Moreover, if they are used in the correct way, they can provide a tremendous help in facilitating instrumentation. This was typically more obvious upon the innovation of M2 Wire with its superior ability of swaging inside the canals and retaining its original shape in an optimum way [13,14,15]. Root canal treatment starts once the involved tooth is approached with a cutting instrument, and final obturation of the canal space will depend mainly on the care and accuracy exercised in this initial step of preparation. However, there are enormous variations and controversies regarding the best methods for preparing root canal systems for perfect obturation.

The current study was conducted to compare and evaluate the ability of two Ni-Ti rotary files; namely, FKG Dentaire files and ProTaper Next filing systems, in the preservation of canal width and degree of taper after instrumentation of curved root canals. Mandibular first permanent molars having curved mesiobuccal canals were selected, then the distal halves were resected at the level of bifurcation. This is to facilitate embedding the mesial roots in transparent acrylic sheets. The two rotary files were used for canal preparation using the crown-down technique following the manufacturer instructions for each system and with a crown-down preparation technique which was found to be significantly better in shaping and preparing curved canals compared to the step-back technique [22]. More studies also show less significant debris extruded from the apical orifice when the crown-down procedures were used rather than the step-back procedures [23].

The FKG system were used to prepare the mesiobuccal canals till file number R3: 30/04 using using Rooters S Cordless endodontic motorized handpiece and contra-angle designed specifically for these files with a speed of 1000 rpm and under a torque of 1 Ncm. while Protaper Next filing system were used to prepare the other mesiobuccal canal specimens till file number X3: 30/0.06 taper prepared using Xsmart Plus contra-angle designed for rotary files with a speed of 300 rpm and under a torque of 2.5 Ncm. In both preparations, irrigation was done with the aid of sodium hypochlorite using a gauge 27 or 30 irrigation needle in conjunction with EDTA as a lubricant agent. Taking care that irrigation after alternate instruments and at completion of filing is a must and that each instrument was used for no more than 6 seconds inside the canal and should also be discarded after three repeated canals or if any signs of unwinding or file distortion is being noticed. All hand pieces are also supplied with an auto-reverse mechanism that operates with a simple 5-level torque limiter. This will allow rotation in the forward direction until 75% of the selected torque limit value is reached, furthermore loading will direct the motor hand piece to reverse its rotation and keep the file against fracture inside the canal.

In the current study, Cone-Beam Computed Tomography (CBCT) had been for used for evaluation of pre and post-measurements, namely, galileos machine (Sirona Dental Systems GmbH, Bensheim, Germany), the scan

parameters were 98 Kv, mA: 3-6 with exposure 14 sec., field of view was 15 X 12 cm and voxel size was 0.125mm. The data was reconstructed in slices of 1mm intervals. This was used together with an accurate software that enable an easy measurement with maximum precise readings. Moreover, this system provides different images manipulation as magnification, zooming, negative to positive inversion, three-dimensional visualization as well as edge enhancement [24,25,26,27,28].

Regarding the degree of canal width changes and root canal diameter following instrumentation in this study, were affected by many variables. These variables include size of the instrument tip that indicates the root canal diameter at the apex, also the file taper which indicates increasing instrumented root canal diameter from apical to coronal third, and instrument eccentric preparation which could result in root canal deviation and corresponding increase in root canal diameter. In the current study, nearly no significant difference was found between both systems at level 1mm and 3mm from the apex. It changed to be slightly different for the PTN system at 5mm level and again up to be of highly significant difference at 7mm level from the apex between the pre-instrumented and post-instrumented canals using PTN system. The PTN had the tendency to enlarge the total canal dimensions at the end of the preparation, which may be actually due to the multiple and progressively taper nature of those files rather than the FKG system, which seems to preserve the original canal width throughout the whole preparation.

5. Conclusion

Under the limitations of this study, and regarding the amount of dentin removed, FKG system appears to remove lesser dentin with more tendency to preserve the canal taper and decrease any unneeded enlargement. However, more investigations under different conditions as sever curvatures and complicated anatomies are highly recommended.

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Conflict of Interest

No conflict of interest was declared by the author in the current study.

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