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Effect of Different Contemporary Rotary Nickel Titanium Systems on Root Canal Geometry

Yasmin Sobh
Endodontic Specialist at General Organization for Teaching Hospitals &Institutes, Cairo, Egypt., dryasmintawfik35@gmail.com

Mohsen Nour EL Deen
Professor of Endodontics, Endodontic Department, Faculty of Dental Medicine for Girls Al- Azhar University, Cairo, Egypt., mohsenmn1@hotmail.com

Ahmed Hashem
Professor of Endodontics, Endodontic Department, Faculty of Dentistry Ain-Shams University, Cairo, Egypt., endohashem@gmail.com

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Effect of Different Contemporary Rotary Nickel Titanium Systems on Root Canal Geometry

Yasmin T. Sobh[1*], Mohsen A. Nour EL Deen[2], Ahmed A. Hashem[3]

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azhardentj@azhar.edu.eg

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ABSTRACT

Purpose: This study aimed to compare NiTi rotary systems of different wires namely; EdgeFiles, Profile GT series X (GTX) and ProTaper (PT) in terms of: canal transportation and centering ability. **Materials and Methods:** One hundred and twenty extracted human mandibular first molars were selected and randomly divided into two main groups (I&II) according to the ranges of curvature (60 teeth each), where group I: samples with 25º- 40º range of curvature and group II: samples with 45º- 60º range of curvature. Each group was subdivided into four subgroups according to the NiTi rotary system (15 teeth each): subgroup A: ProTaper, subgroup B: Profile GT Series X, subgroup C: EdgeFile X3 and subgroup D: EdgeFile X5. The root canals were scanned by i -CAT CBCT scanner before and after instrumentation at 3, 5 and 8 mm levels from the apex, to assess the canal transportation and centering ability. **Results:** The EdgeFile system produced the least canal transportation and remained more centered around the original canal than the other systems. While, PT system produced significantly the highest canal transportation and the least centered canal preparation than other systems. **Conclusions:** EdgeFile systems showed superior performance regarding maintenance of the original root canal curvature and centering ability than do other systems.

KEYWORDS

Canal transportation, EdgeFile, Profile GT Series X, ProTaper

INTRODUCTION

One of the condemnatory parts of root canal treatment is canal shaping due to procedural errors that can happen during cleaning curved canals [(1)]. A number of different.

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1. Endodontic Specialist at General Organization for Teaching Hospitals &Institutes, Cairo, Egypt.
2. Professor of Endodontics, Endodontic Department, Faculty of Dental Medicine for Girls Al- Azhar University, Cairo, Egypt.
3. Professor of Endodontics, Endodontic Department, Faculty of Dentistry Ain-Shams University, Cairo, Egypt.

* Corresponding author email: dryasmintawfik35@gmail.com

Technologies have been done to overcome these problems,which include the introduction of the super-elastic nickel-titanium (NiTi) rotary instruments. In severely curved canals,there were minimal pressure applied on the canal walls owing to the superelasticity of NiTi rotary files that decreasing the danger of canal variation and better preserving the actual shape of the canal [(2)].

However, in clinical practice, these instruments may be subjected to fracture, mainly because of flexural (fatigue fracture) and torsional stresses[(3)]. Torsional stresses may be increased with a wide area of contact between the canal walls and the cutting edge of the instrument[(4)].To reduce such stresses, the ProTaper rotary design combines multiple progressive tapers.

The ProTaper rotary instrument has progressive tapers sequence along the shaft compared with the constant taper embraced by the other tested systems, variable helical angle and pitch over the length of their cutting blades that leading to greater cutting ability of ProTaper [(5)]. ProTaper files has rounded non cutting tip this design allow the instrument to follow the canal glide path [(6)].

It has been reported that, ProTaper rotary files maintaining the original canal curvature than ProTaper hand files, where they produced lesser transportation and remained better centered in the canal [(7)]. On the Other hand, it has been reported that ProTaper tended to transport towards the outer aspect of the curve compared to RaCe instruments[(8)].

Profile GT Series X was the rotary system that manufactured from M wire alloy as consequences of adding successions of thermal treatments to NiTi wire.The manufacturer claims that, this material has great flexibility and an increased resistance to cyclic fatigue than traditional NiTi alloy. Moreover, the changeable radial lands are characteristic feature of the Profile GT Series X rotary system which are suggested to decrease the effect of the instrument on the outside of the root canal curve, thus keeping the file concentric within the canal, prevents the file from locking in the dentin, therefore increasing the cutting efficiency without transportation [(9-11)].

“Fire-Wire” NiTi alloy that have been introduced by annealing heat treatment which is an example of Thermo-mechanical enhancements. EdgeFile NiTi rotary file is the example of the heat treated Fire-Wire.It has parabolic cross section. The manufacturer suggested that EdgeFile has high cyclic fatigue resistance. Maintaining apical anatomy and minimizing canal transportation can be implemented by Heat-treated FireWire nickel-titanium [(12)].Therefore, this study aimed to compare NiTi rotary systems of different wires namely; EdgeFiles, Profile GT series X (GTX) and ProTaper (PT) in terms of canal transportation and centering ability.

MATERIALS and METHODS

Selection of teeth and specimens preparation:

One hundred and twenty extracted human mandibular first molars with completely formed roots were used in this study. The mesial root length was about 20 to 21 mm, two separate mesial canals that terminate with two separate apical foramina. The teeth were then divided into two groups according to Schneider technique [(13)] the ranges of curvature; group I (25-40) degree and group II (45-60) degree (60 teeth each).

A round bur and Endo-Z bur in a high speed handpiece were used to perform the access cavity. Subtracting 1 mm from the length of the used file as it first protruded from the canal to indicate the working length. A tapered diamond stone in a high speed hand piece was utilized to detach the distal roots with the corresponding section of the crown.

Each group was subdivided into four subgroups according to the NiTi rotary system (15 teeth each). Subgroup A: ProTaper rotary system, subgroup B: Profile GT Series X (GTX) rotary system, subgroup C: EdgeFile X3 rotary system and subgroup D: EdgeFile X5 rotary system. A crown-down sequence was used to prepare each canal to the working length, where # 30 file was selected to be the final file for canal preparation in each group.

Irrigation with 2 mL 2.6 % NaOCl was performed between each successive file size, employing a 27-G needle. A #10 K-file was utilized to preserve canal patency. Each instrument was discarded after using it in 5 canals.

Image analysis:

Before and after instrumentation, teeth were scanned by i-CAT CBCT scanner. The parameters for exposure were 85 kV and 16 mA. The height was 7.5cm in the field of view and was 14.5 cm width. Slices were 640 _ 640 pixels, and the size of the pixel was 0.5 mm with the definite angle 5 degrees to indicate the degree of curvature of the mesial and distal dentin thickness of the canal before the instrumentation. Acquired data were monitored, and measurements were performed by the software on demand 3D, Seoul, SouthKorea, operating system windows XP SP3.The remaining dentin thickness was measured after tracing the mesiobuccal canal. The apical end of the root were viewed at three cross-section planes at different levels 3,5, and 8mm from the apex .

The remaining dentin thickness and transportation of the canal was measured at each level according to the following formula : (x1-x2) - (y1-y2) While ,(x1-x2)/(y1-y2) or (y1-y2)/(x1-x2) was used to measure canal centering ability where x1 was the shortest distance in mesial side of the root canal before instrumentation ,x2 was the shortest distance from the mesial side of the root canal after instrumentation y1 was the shortest distance distal side of the root canal before instrumentation and y2 was the shortest distance from distal side of the root canal after instrumentation as in fig.(1)

RESULTS

A-Canal Transportation

A-I Range of curvature (25º- 40º):

At 3 and 5mm levels from the apex; the PT system produced the statistically highest canal transportation with a significant difference compared to the Profile GTX, and EdgeFile systems (P<0.05). However, there was no significant difference between EdgeFile systems, X3 and X5 (P>0.05).

While, at 8mm level from the apex, the PT system produced the statistically highest canal transportation compared to the Profile GTX, and EdgeFile X3 which produced the lowest canal transportation. However, there was no significant difference between the Profile GTX and EdgeFile X5 (P>0.05).

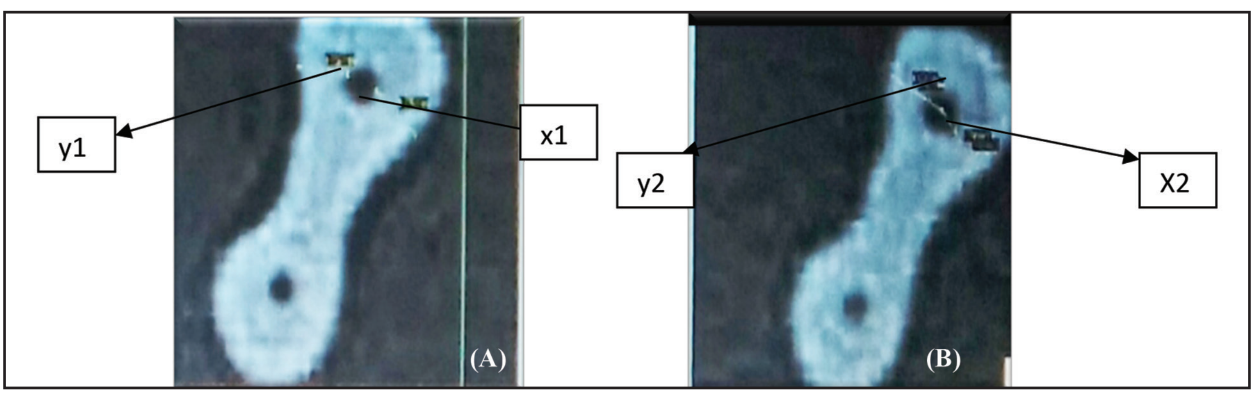

Figure (1) Remaining dentin thickness (A): before, (B): after instrumentation at 3 mm level from the apex.

A-II Range of curvature (45º- 60º):

At 3mm level from the apex, the PT system produced the statistically highest canal transportation with a significant difference compared to the Profile GTX, and EdgeFile systems (P<0.05). However, there was no significant difference between EdgeFile systems, X3 and X5 (P>0.05).

While, At 5mm and 8mm levels from the apex, the PT system produced the statistically highest canal transportation with a significant difference compared to the Profile GTX, and EdgeFile systems(P<0.05). However, there was no significant difference between the Profile GTX, EdgeFile systems, X3 and X5 (P>0.05). (Table 1, fig.2).

Table (1): *Comparison of canal transportation among the tested rotary systems at three levels of the root canal in both ranges of canal curvatures (25º- 40º) & (45º- 60º).*

Canal transportation (25º-40º)	Level (mm)			Canal transportation (45º -60º)	Level (mm)		
	3mm	5mm	8mm		3mm	5mm	8mm
Protaper				**Protaper**			
Mean±SD	0.23±0.20a	0.24±0.19a	0.19±0.14a	Mean±SD	0.18±0.13a	0.20±0.10a	0.14±0.17a
Range	-0.3_0.4	-0.2_0.4	-0.1_0.5	Range	-0.1_0.3	0_0.3	-0.2_0.3
Profile GTX				**Profile GTX**			
Mean±SD	0.13±0.09b	0.11±0.08b	0.14±0.08b	Mean±SD	0.13±0.11b	0.07±0.10b	0.10±0.08b
Range	0_0.3	0_0.2	0_0.2	Range	-0.1_0.3	-0.1_0.3	0_0.2
EdgeFile X3				**EdgeFile X3**			
Mean±SD	0.08±0.08c	0.07±0.09c	0.07±0.09c	Mean±SD	0.07±0.09c	0.10±0.08b	0.06±0.18b
Range	0_0.2	0_0.2	0_0.2	Range	0_0.3	0_0.3	-0.5_0.3
EdgeFile X5				**EdgeFile X5**			
Mean±SD	0.07±0.09c	0.07±0.08c	0.12±0.09b	Mean±SD	0.08±0.14c	0.11±0.14b	0.05±0.19b
Range	0_0.2	0_0.2	0_0.3	Range	-0.1_0.4	-0.1_0.4	-0.4_0.3
ANOVA test	3.996	4.517	16.784	***ANOVA test***	3.464	5.035	1.934
p-value	<0.001**	<0.001**	<0.001**	***p-value***	<0.001**	<0.001**	0.046*

*Using: One Way ANOVA; *p-value <0.05 S; **p-value <0.001 HS*

Post Hoc: Columns with different small letters denote significant

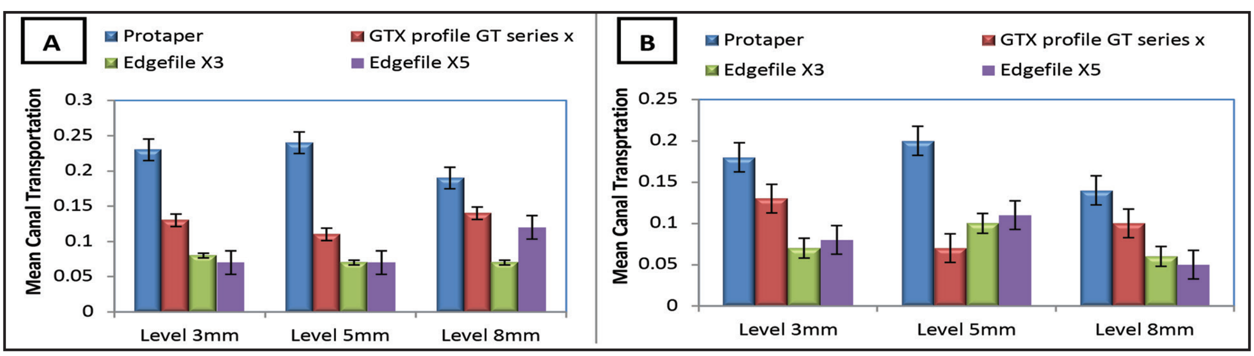

Figure (2) Bar charts comparison the canal transportation among the tested rotary systems at three levels of the root canal in both ranges of canal curvatures; A (25º- 40º) & B (45º- 60º).

B-I Range of curvature (25º- 40º):

At 3, 5 mm levels from the apex; the PT system produced the statistically lowest centering ability with a significant difference compared to the Profile GTX, and EdgeFile systems (P<0.05). However, there was no significant difference between EdgeFile systems, X3 and X5 (P>0.05).

At 8mm level from the apex, there was a statistical significance difference between all rotary systems (P<0.05). Where, EdgeFile X3 system produced the statistically highest centering ability than the other rotary systems (P<0.05).

B-II Range of curvature (45º- 60º):

At 3mm level from the apex, the PT system produced the statistically lowest centering ability compared to the Profile GTX, and EdgeFile systems (P<0.05). While, EdgeFile X3 system, produced the statistically highest centering ability than the other rotary systems (P<0.05).

At 5 mm level from the apex; the Profile GTX, produced the statistically highest centering ability with a significant difference compared to the PT system, and EdgeFile systems (P<0.05). However, there was no significant difference between PT system and EdgeFile systems, X3 and X5 (P>0.05).

At 8mm level from the apex, there was a statistical significance difference between all rotary systems (P<0.05).Where, the ProFile GTX system produced the statistically highest centering ability than the other rotary systems (P<0.05). (Table 2, fig.3).

Table (2) *Comparison of canal centering ability among the tested rotary systems at three levels of the root canal in both ranges of canal curvatures (25º-40º)&(45º-60º).*

Centric ability (25º-40º)	**Level (mm)**			**Centric ability (45º -60º)**	**Level (mm)**		
	3mm	**5mm**	**8mm**		**3mm**	**5mm**	**8mm**
Protaper				**Protaper**			
Mean±SD	0.44±0.17c	0.37±0.21c	0.49±0.20d	Mean±SD	0.57±0.15d	0.55±0.22b	0.47±0.15d
Range	0.16_0.75	0_0.71	0.25_1	Range	0.25_0.77	0.25_1	0.25_0.66
ProfileGT X				**Profile GT X**			
Mean±SD	0.72±0.15b	0.75±0.18b	0.68±0.17c	Mean±SD	0.72±0.13b	0.90±0.09a	0.79±0.13a
Range	0.5_1	0.5_1	0.5_1	Range	0.5_1	0.7_1	0.6_1
EdgeFile X3				**EdgeFile X3**			
Mean±SD	0.86±0.13a	0.87±0.16a	0.87±0.16a	Mean±SD	0.87±0.16a	0.64±0.23b	0.61±0.29c
Range	0.66_1	0.6_1	0.6_1	Range	0.6_1	0.5_1	0.25_1
EdgeFile X5				**EdgeFile X5**			
Mean±SD	0.85±0.18a	0.86±0.16a	0.79±0.16b	Mean±SD	0.69±0.21c	0.59±0.28b	0.76±0.17b
Range	0.5_1	0.6_1	0.5_1	Range	0.33_1	0.2_1	0.33_1
ANOVA test	10.749	10.373	8.126	***ANOVA test***	7.492	8.065	7.006
p-value	<0.001**	<0.001**	<0.001**	***p-value***	<0.001**	<0.001**	<0.001**

*Using: One Way ANOVA; **p-value <0.001 HS*

Post Hoc: Columns with different small letters denote significant

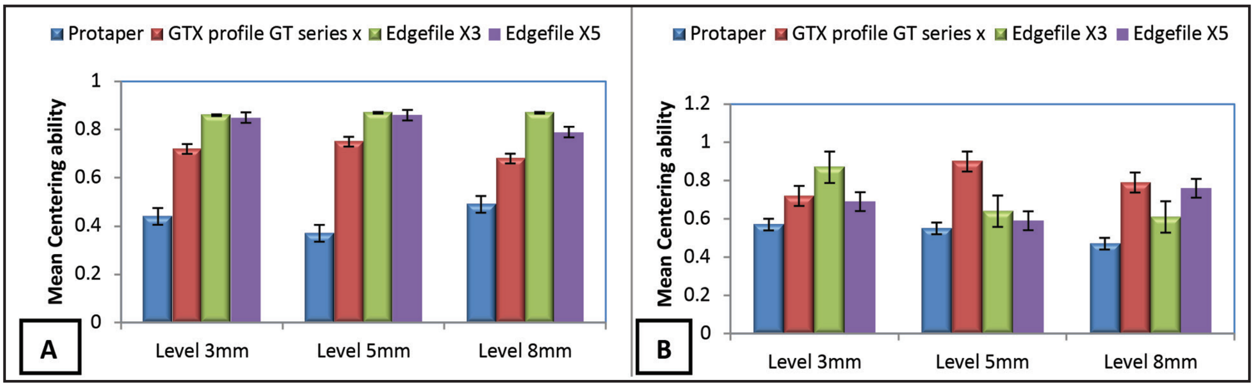

Figure (3) Bar charts comparison the canal centering ability among the tested rotary systems at three levels of the root canal in both ranges of canal curvatures; A (25°- 40°) & B (45°- 60°).

DISCUSSION

One of the important stages of endodontic treatment is shaping of the root canal. Nevertheless, one of the obstacles in root canal instrumentation is canal curvatures as it can create procedural errors. Sophisticated anatomic characteristics can be managed easily and safely by Ni Ti instruments [1].ProTaper, Profile GTX and EdgeFile are distinctly different in their geometrical design and manufacturing methods.

None of the currently available rotary systems were totally effective in performing perfect biomechanical preparation of curved root canals without transportation so; there are continuous trials to introduce new file systems to overcome the disadvantage of the previous systems [14].

An extracted human teeth was used in this study because trying out rotary Ni –Ti file systems under practical conditions in natural dentin are more favorable than artificial canals [15].

In the present study, the curvatures of root canals were ranged between (25°-40°) and (45°-60°) according to Schneider technique [13] based on the preoperative Cone-Beam computed tomography scanning (CBCTs). Five canals were enlarged by each instrument according to the instructions that regulated by manufacturer.

An accurate 3diemensional assessment of changes in root canal morphology can be done by non interfering CBCT pre and post instrumentation without interruption of the specimens [16]. Owing to lateral forces transmitted from files in apical area during root canal preparation[9],therefore measurements had been chosen at the three selected levels (3, 5, 8 mm) from the apex.

In first range of canal curvature (25°-40°), at the coronal region, EdgeFile X3 system remains more centered and produced least canal transportation. While, in the other range of canal curvature (45°-60°) EdgeFile X3 system remains more centered apically than the other systems.This is in agreement with other studies [17--18].These finding may be related to the increasing in flexibility, the resistance to torosional and cyclic fatigue of the instruments[19]. Furthermore, the parabolic design were in charge of minimal pressure on the lateral wall of canals [20].While on the other contradictory study, they evaluated the shaping ability of the XP Endo Shaper, iRaCe, and EdgeFile systems using micro-CT technology,their results showed all systems have a similar shaping ability, may be related to the using of mandibular incisor oval canals[21].

Concerning canal transportation and centering ability, there were different geometric designs of EdgeFile X3, EdgeFile X5, Profile GTX, and ProTaper. Moreover, EdgeFile system had an outstanding capability in shaping curved canals than other rotary systems. The file metallurgy and design features could be responsible for these findings which were consistent with previous reports [17-20].

In the (45°-60°) range of canal curvature, at the mid and coronal portions, the innovated method of manufacturing Profile GTX rotary system remained more centered than the other systems.These results were consistent with other studies [9-11].These findings might be owing to M wire NiTi alloy with reduced core diameter that work together to increase flexibility. Furthermore, the unique feature of variable-width lands was reported to minimize the taper lock in the canal and to produce larger chip space between cutting flutes allowing for rapid efficient cutting without transportation. Moreover, the radial lands on the cutting edges of the file allowed more circumferentially uniform cutting to occur compared with the actively cutting files without lands [9].

On the contrary, another studies was reported that TF system resulted in superior shaping ability in curved canals, with the instruments remaining more centered and producing less canal transportation than GTX rotary system [22-23].

While another finding reported that the TF and GTX NiTi rotary instruments showed similar shaping abilities [24].

Regarding the middle level which represents the beginning of curvature which is anatomically different from the other two-thirds. It is considered straighter portion compared with apical third; which in turn will be subjected to minor effect of lateral forces transmitted from files used for canal preparation [14].

Regarding the centering ability and transportation, ProTaper rotary system recorded highest mean value of canal transportation and least centric ability when compared with the other tested rotary instruments. This was in agreement with previous studies[8,9,25].These findings could be attributed to the sharp cutting edges of the convex triangular cross sectional design and the multiple tapers along the cutting surface of the files compared with the constant taper embraced by the other tested instruments used. In addition, the apical enlargement performed until F3 for standardization might have an impact on the results because NiTi files with tapers greater than 0.04 were previously suggested not be used for apical enlargement of curved canals or else transportation would result [9].

Moreover, the progressive taper design of Protaper rotary system, increased tendency for canal transportation due to reduction in instrument flexibility and increased tip stiffness of the file [5].On the other hand, another contradictory findings were reported that no significant difference among ProTaper,Hero 642, and Twisted File rotary systems in terms of canal transportation and centering ability[26] .

CONCLUSIONS

Within the limits of the current study; Properties of file systems (metal alloy) have an impact on canal transportation and centering ability. All tested rotary systems produced canal transportation at the canal levels. EdgeFile systems showed superior performance in preventing canal transportation. Edgefile maintained the root canal more centered in the apical area than other systems.

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