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EVALUATION OF SHAPING ABILITY OF MPRO AND PROTAPER NEXT NITI ROTARY INSTRUMENTS USING CONE BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

Aim: present study was intended to compare the mechanical behavior of PTN and MPro NiTi rotary systems and the associated canal volumetric changes in curved root canals.

Materials and methods: 50 freshly extracted permanent first mandibular molars were collected then reduced to 19 mm length and the distal roots were dissected. Mesial roots were then embedded in upright positions within acrylic resin blocks. The samples were randomly assigned into 2 groups (n=25) and prepared with either ProTper Next to X2 file or with MPro files to 25/0.06 file. CBCT scans were performed on the samples before and after root canal preparation with the NiTi rotary systems. Root canal transportation, instrument centering ability and remaining dentine thickness were calculated at 1, 3, 5, 7, and 9 mm from the root apex. Additionally, pre and post instrumentation root canal space through the apical 9 mm of the root were segmented and measured.

Results: MPro system significantly transported the root canals at all tested levels compared to the PTN system. Roots prepared with PTN had significantly more dentin thickness at the distal canal wall at levels 5, 7, and 9 mm from the apex, than those prepared with the MPro system. MPro rotary system removed dentin volume in apical 9 mm significantly more than ProTaper Next system and created larger post-instrumentation canal volume.

Conclusion: The ProTaper Next system prepared the mesiobuccal root canals of extracted mandibular molar with more uniform and centered instrumentation across the canal length than MPro rotary system.

KEYWORDS : ProTper Next, MPro, remaining dentine, canal volume, transportation

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INTRODUCTION

The primary objective of endodontic treatment is to disinfect the root canal while preserving its original morphology and trajectory, avoiding any canal distortions [1]. Technological advancements in endodontic instrumentation have facilitated the development of various nickel-titanium (NiTi) rotary systems with variable instrument design features and alloy composition aiming to achieve better and safer root canal shaping while reducing the risk of procedural accidents, such as transportation, reduced remaining dentin thickness, or file separation [2,3].

Increased taper associated with NiTi rotary instruments has been introduced as an acceptable clinical approach in order to facilitate canal preparation with less number of instruments and to provide greater degree of canal funneling [4,5]. It has been stated that increased canal tapering allows better access for canal cleaning and disinfection [6–8]. However, root canal preparation should ensure adequate flare while avoiding excessive dentin removal [9]. Excessive removal of dentine during mechanical root canal instrumentation comprises the root integrity that may progress to root fracture [10] .

ProTaper Next (PTN) (Dentsply Sirona, Ballaigues, Switzerland) is a rotary file system utilizing M-Wire, characterized by an off-centered rectangular cross-section alloy that is specifically heat-treated to improve the instrument's flexibility [11]. It utilizes multi-taper designed files, which aid in faster and safer root canal preparation with a more centered approach [12]. MPro (Innovative Material and Devices (IMD), Shanghai, China) is a rotary NiTi file fabricated from heat-treated wire that allows the file to be more bendable, providing greater flexibility and improved fracture resistance [13]. The MPro file is designed with a convex triangular cross-section, with tip diameters ranging from #18 to #25 and a variable taper of 4-8% from the tip to the coronal portion.

Therefore, the present study was intended to compare the mechanical behavior of PTN and MPro NiTi rotary systems and the associated canal volumetric changes in curved root canals.

MATERIALS AND METHODS

Ethical approval

The study protocol was reviewed and approved by the Research Ethics Committee of the Faculty of Dentistry, Mansoura University, Mansoura, Egypt (#M0209023)

Sample size calculation

Sample size was calculated using G*Power software, with a medium effect size of 1.1, an alpha error of 0.05, and a power of 0.95, The anticipated sample size was not less than a total of 46 specimens. Accordingly, 50 samples were collected to be involved in the present study.

Sample collection and preparation

Fifty freshly extracted permanent first mandibular molars were collected from the oral surgery clinics at the Faculty of Dentistry, Mansoura University. Teeth were extracted for reasons that are not related to the present study, e.g., periodontal, or orthodontic reasons. The collected teeth were initially cleaned using an ultrasonic cleaner, disinfected in a 5.25% sodium hypochlorite solution for 5 minutes, and then kept in a 0.1% thymol solution until further usage. The inclusion criteria for the study were: fully formed apices, two separate roots, mesial root with a type IV Vertucci canal configuration [14], average root length 10-12 mm, canal curvature of 20-30 degrees according to the Schneider method [15], and absence of intra-pulpal calcifications, internal resorption defects, or external root defects. Teeth exhibiting immature apices, calcification, root resorption (internal or external), severe curvature, multidirectional curves, root fractures, cracks, or prior root canal treatment were excluded from the study.

After disinfecting the teeth, they were two dimensionally radiographed using a FONA CMOS sensor (CDR Elite, Fona Dental Inc., Bratislava, Slovakia) and examined under high magnification with a dental operating microscope (Zumax OMS2380, Zumax medical ltd, Suzhou, China) to confirm the inclusion criteria and ensure the absence of any pathological involvement. Any tooth that did not meet the inclusion criteria was excluded and replaced.

The occlusal surfaces of the teeth were subsequently reduced to standardize the tooth length at 19 mm. A conventional access cavity was then prepared, and the distal roots were dissected. All mesial roots were then embedded in upright positions within acrylic resin blocks.

The patency of the mesiobuccal canal was confirmed using a size 10 K-file, which was introduced from the root canal orifice until its tip was observable at the apex. The definitive working length (WL) was established as the distance from the occlusal reference point to 1 mm less than the length of the #10 K-file. A mechanical glide path was subsequently established utilizing a #15 K-type file, operated with a watch-widening motion, to the working length of the root canals.

Preoperative CBCT scanning:

CBCT scaning were performed on the samples embedded in resin blocks before root canal preparation with NiTi rotary systems. The scans were acquired using the Veraview X800 CBCT machine (Veraview X800, Morita Corp, Japan) with a limited field of view of 40×40 mm, a voxel size of 80 microns, and acquisition parameters of 90 Kvp, 8 ma, and 17 seconds.

Sample grouping and root canal preparation:

Root samples were numbered and randomly assigned to two groups using random allocation software (https://www.sealedenvelope.com/simple-randomiser/v1/lists), corresponding to the different NiTi rotary instrumentation systems to be utilized for preparation of the mesiobuccal canals (n=25). The mesiobuccal canals were then instrumented using the following the manufacturer's instructions:

PTN group: root canals were prepared with PTN system using x1 and x2 (#25/06% taper) to the full WL.

MPro group: root canals were prepared with MPro system using 20/.04 and 25/.06 sequentially to the full WL.

As a standard preparation protocol for both rotary systems, complete canal preparation was considered when the rotary file operated the root canal with three long gentle picking motions at the WL. Each canal was recapitulated using a #10 K-type file and irrigated with 2 ml of 2.5% sodium hypochlorite solution using a 30-gauge needle (Fanta Dental Corp, Shanghai, China) between the use of each file or in case the rotary file suffered to reach the apex. Each rotary file prepared only five canals before disposal.

Postoperative CBCT scanning:

All samples were radiographed using CBCT similar to the former radiographic acquisition settings.

Assessment of root canal transportation and instrument centering ability:

Root canal transportation and instrument centering ability was calculated at 1, 3, 5, 7, and 9 mm from the root apex at axial view of DICOM volume using the formulas [16]:

Canal transportation = (m1-m2) - (d1-d2)

Where m1 and m2 were the shortest distances between the mesial root margin and the canal margin in un-instrumented and instrumented samples respectively. While d1 and d2 were the shortest distances between the distal root margin and the canal margin in un-instrumented and instrumented root samples (figure 1). According to the formula, any result other than zero indicates canal transportation. While instrument centering ability was measured as:

Centering ratio = (m1-m2)/(d1-d2) or (d1-d2)/(m1-m2)

If the values of removed dentine at both sides were not the same, the smaller value was selected as the numerator in the ratio. This approach indicates that a value of 1 signifies ideal centering. To minimize positional discrepancies when measuring dentin thickness at the same levels before and after instrumentation, the DICOM volumes were superimposed and registered using ITK-Snap software (ITK-snap 3.0 software, Cognitica, Philadelphia, Pa, USA)

Assessment of canal volumetric changes:

Using semi-automatic segmentation approach, pre and post-instrumentation root canal space at the apical 9 mm of the root were segmented (figure 2). Volumes of the segmented spaces were measured in itk-snap software. The difference in the volume measurements before and after instrumentation was defined as the volume removed during preparation.

Statistical analysis

Kolmogorov-smirnov and shapiro-wilk tests were used to detect normality of data distribution and accordingly student t-test was used to detect significance between the tested groups at different root levels concerning root canal transportation, centering ability, pre canal volume, post canal volume and volume of removed dentine. Paired t-test was used to detect significance between pre canal volume and the post canal volume within the same group.

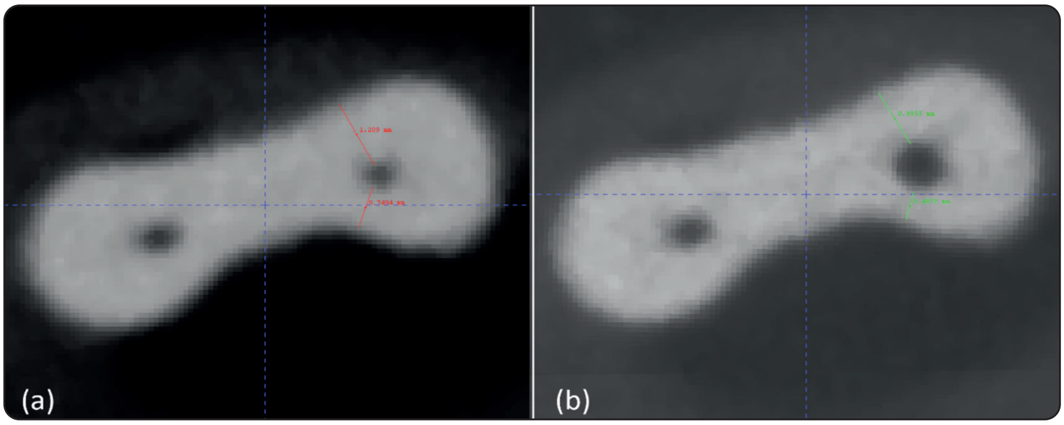

Fig. (1) Showing measuring the dentin thickness at mesial and distal walls in pre (a) and post (b) instrumentation DICOM image in axial view.

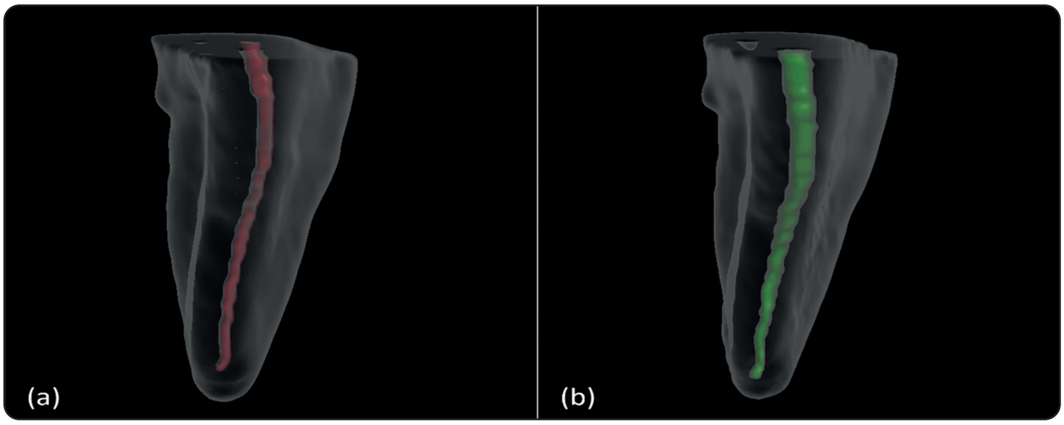

Fig. (2) Showing 3D models of pre (a) and post (b) instrumentation segmented volumes of the apical 9 mm of mesial root and the related mesiobuccal canal

RESULTS

Data describing canal transportation and centering ability of the two rotary systems are presented in a table (1). Statistical analysis using the student's t-test revealed that the MPro system significantly increased root canal transportation at all tested levels compared to the PTN system. Regarding centering ability, there was no significant difference between the groups, except at 1 mm from the apex, where PTN demonstrated better centering. When considering the remaining dentin thickness after instrumentation, roots prepared with PTN had significantly more dentin thickness at the distal canal wall at levels 5, 7, and 9 mm from the apex, compared to those prepared with the MPro system (table 2 and figure 3).

The initial root canal volume was similar between the groups (p=0.42) (figure 4), and both systems significantly increased the canal volume after instrumentation (p<0.00 for both rotary systems). However, the MPro rotary system removed significantly more dentin (p<0.00), resulting in a larger post-instrumentation canal volume compared to the PTN system (p<0.00) (figures 4,5).

TABLE (1) Showing the mean ± standard deviation of root canal transportation (mm) and centering ability of tested files in mesio-distal dimension at various levels:

		1 mm	*3 mm*	*5 mm*	*7 mm*	*9 mm*
Transportation		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ±SD
	PTN	0.08 ± 0.04	0.08±0.04	0.07±0.03	0.09±0.04	0.11±0.06
	MPro	0.11 ± 0.05	0.16±0.04	0.10±0.07	0.14±0.11	0.27±0.07
	P- value	0.00	0.00	0.02	0.03	0.00
Centering ability	PTN	0.51 ± 0.20	0.41±0.20	0.68±0.43	0.70±0.17	0.54±0.19
	MPro	0.48 ± 0.13	0.48±0.03	0.72±0.16	0.71±0.21	0.55±0.12
	P-value	0.56	0.19	0.21	0.85	0.76

Values at the same column are significantly different if P<0.05

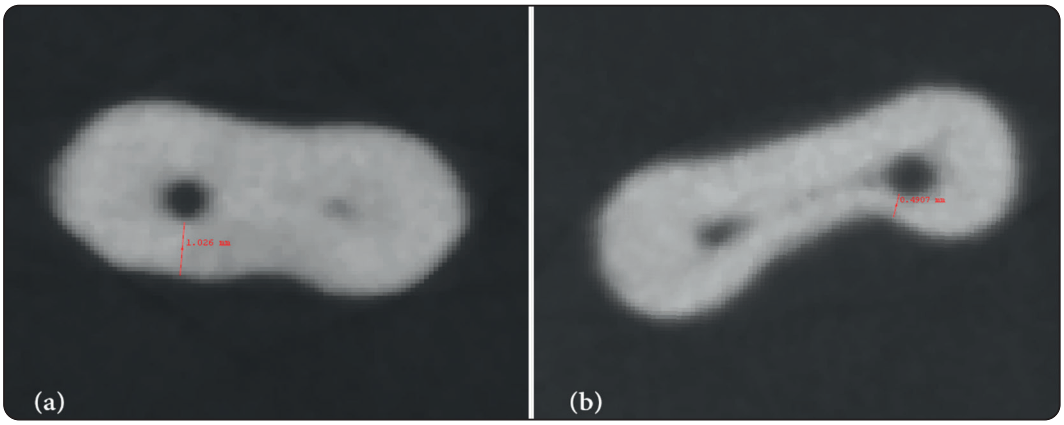

Fig. (3) showing representative image of remaining dentine thickness (mm) of distal wall at 9 mm from the apex after preparation with PTN (a) and MPro (b).

TABLE (2) Showing the mean ± standard deviation of root canal remaining dentine thickness (mm) in mesial and distal walls at various levels:

	Level	PTN	MPro	p- value
		mean±SD	mean±SD	
Mesial wall	1	0.67±0.22	0.56±0.21	0.67
	3	0.81±0.26	0.67±0.19	0.08
	5	0.83±0.25	0.81±0.25	0.84
	7	0.78±0.23	0.75±0.28	0.69
	9	1.05±0.25	0.95±0.34	0.29
Distal wall	1	0.61±0.2	0.65±0.25	0.51
	3	0.91±0.23	0.83±0.22	0.20
	5	0.91±0.18	0.70±0.17	0.00
	7	0.88±0.19	0.61±0.19	0.00
	9	1.17±0.18	0.73±0.21	0.00

Values at the same row are significantly different if P<0.05

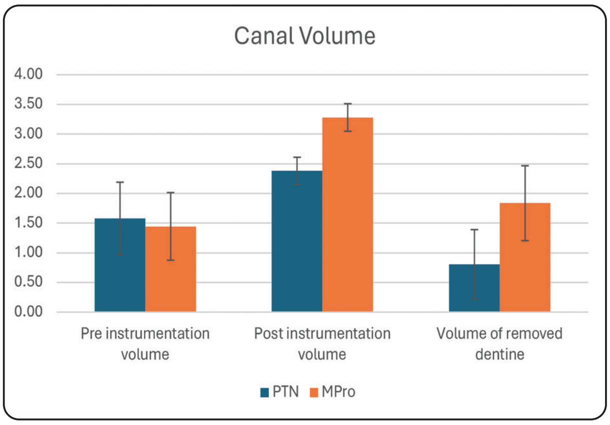

Fig. (4) showing the mean ± standard deviation of change of volumetric dimensions related to pre and post instrumentation canal volume (mm3).

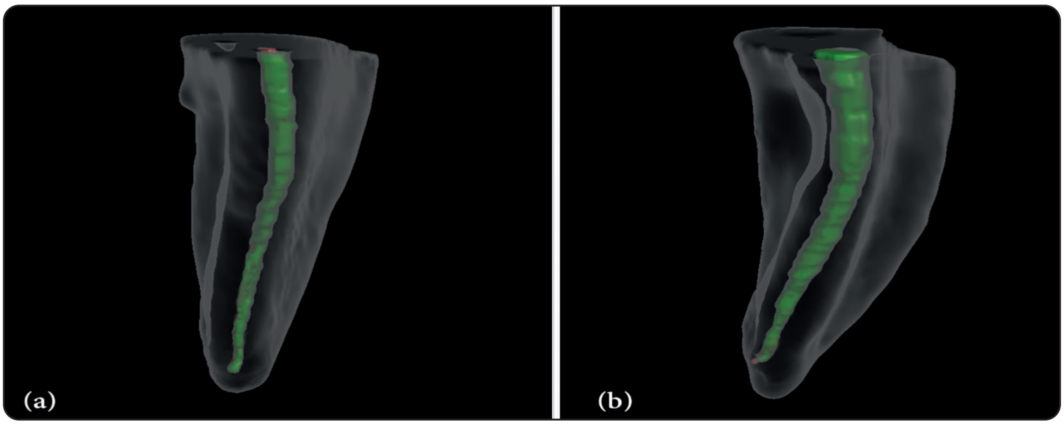

Fig. (5) showing representative 3D model of segmented roots and the related mesio-buccal canal after preparation with PTN (a) and MPro (b) rotary systems.

DISCUSSION

The present study was to compare the shaping ability and the resulted canal volumetric changes after instrumentation of curved root canals with PTN and MPro NiTi rotary systems. According to current results, there was a significant difference between PTN and MPro regarding shaping ability at all tested root levels in addition to the related volumetric changes in canal space, therefore, the null hypothesis could be rejected.

The current study analyzed mesiobuccal root canals of extracted human mandibular molars. The utilization of natural teeth provided a more accurate representation of clinical conditions, accounting for factors like dentin hardness and canal irregularities [17]. Mesiobuccal root canals were evaluated as they often exhibit pronounced curvature in both the mesio-distal and buccolingual planes, leading to increased canal transportation during instrumentation compared to most other canals [18].

CBCT was chosen for its accuracy, reliability, and ability to generate three-dimensional images [19].

While the MPro rotary system has reported to demonstrate excellent resistance to cyclic fatigue compared to other rotary systems [13,20], its mechanical behavior during root canal shaping has not been extensively investigated in the literature, despite its widespread clinical use. The PTN rotary NiTi file system was selected for comparison, as it is a widely used reference technique, and its dimensions are similar to the MPro rotary system at the selected levels. The comparison was made using standardized tooth length and the instrumentation was performed to the same post-instrumentation apical diameter, equal to the size of #25/0.06 [5]. The present study focused on the morphological canal changes caused by the main files in both systems, thus, the tested files were allowed to prepare the canals without canal pre-flaring to maximize the potential effect of transportation caused by the two systems [21].

Despite the similarity of instrument taper and tip diameter between both systems at the tested levels, the PTN system demonstrated lower values regarding canal transportation compared to the MPro rotary system. This result can be attributed to differences in the design features and cross-sectional geometry of the files. The PTN files have an off-centered rectangular cross-section, which may allow for more uniform and centered instrumentation across the canal curvature [22]. In contrast, the MPro files have a convex triangle cross-section. This finding corroborates previous investigations [18,23] which reported that PTN files caused less canal transportation compared to triangular or convex triangle cross-section files. Additionally, files with asymmetric cross-sections have been reported to have a smaller core surface area, which can contribute to increased flexibility [24]. The present results are comparable to those reported by Fikry et al. [25], who found inferior performance of the MPro system compared to the ProTaper Universal. However, present findings contradict the results of previous research [26,27] that found no significant difference regarding canal transportation between the MPro and PTN systems. This contradiction may be attributed to differences in radiographic acquisition settings, CBCT image resolution, instrumentation protocols, or the measurement levels used. Despite the current results, it is important to note that according to Wu et al. [28], the apical seal of endodontic treatment may be compromised if apical transportation exceeds 0.3mm, however, MPro system did not exceed that value.

Regarding the remaining dentin thickness, it is important for instruments with large taper to properly shape the canal without significantly decreasing the amount of remaining root dentin, especially in the furcal area of the teeth. This is crucial to reduce the incidence of strip perforations and root fractures [29,30]. The current study found that the roots prepared with the MPro system had significantly less remaining dentin thickness at the coronal levels of the distal canal wall compared to those prepared with the PTN system. This may be attributed to the increased stiffness and larger core surface area of the MPro instruments. In contrast, the PTN files were reported to have reduced instrument contact with the canal walls [22], which helped preserving the dentin thickness in the furcal area, where file flexibility decreases significantly due to the increased taper and diameter. Our results are consistent with previous studies [23,31,32] that reported preserved dentin cutting with the PTN rotary files. To the best of our knowledge, no published data currently exist regarding the remaining dentin thickness following root canal preparation using the MPro system.

As far as the volumetric changes are concerned, the present study found that both NiTi systems significantly increased the root canal volume after instrumentation, but the increase was more pronounced with MPro than with PTN. This can be attributed to the increased cutting efficiency of the MPro files and its increased stiffness in comparison with PTN files. it is important to note that increasing the canal volume may aid in better cleaning of canal space [8], however, the increase of canal volume occurs on expense of remaining root dentine and may jeopardize the root integrity [9,10]

CONCLUSION:

Within the limitation of the study, the ProTaper Next system prepared the mesiobuccal root canals of extracted mandibular molar with more uniform and centered instrumentation across the canal length than MPro rotary system.

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