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Research Article

Assessment of Shaping Ability of One Curve Single-File in Comparison to Multiple-Files Protaper Next Rotary System. (A Comparative *in Vitro* Study)

Renad Mazin Al-Shawwa[1]*, Heba El Asfouri[2] and Khaled Ezzat[3]

[1]Master Degree in Endodontics, Faculty of Dentistry, Cairo University, Egypt

[2]Associate Professor of Endodontics, Faculty of Dentistry, Cairo University, Egypt

[3]Professor of Endodontics, Faculty of Dentistry, Cairo University, Egypt

***Corresponding Author:** Renad Mazin Al-Shawwa, Master's degree in Endodontics, Faculty of Dentistry, Cairo University, Egypt.

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Abstract

Aim: The study attempted to evaluate the shaping ability of One Curve single file in comparison to ProTaper Next multiple-file NiTi in terms of transportation and centering ability in curved mesiobuccal canals of human extracted mandibular molars using CBCT scanning.

Materials and Methods: Mesiobuccal canals of thirty extracted mandibular first and second molars with the angle of curvature ranging 20-45° (according to Schneider) were randomly allocated into two equal groups; One Curve (OC) and ProTaper Next (PTN) groups. Pre- and post-instrumentation CBCT imaging was performed to assess the centering ability and canal transportation of the tested instruments at 3, 5 and 8 mm from the apex.

Results: Regarding the results of canal transportation and centering ability, there was no statistically significant difference mesiodistally among the two groups at 3, 5, and 8mm (P > 0.05).

Conclusion: The canal transportation values of the two tested rotary systems are considered acceptable. Both of One Curve and ProTaper Next systems were not able to achieve perfect centering ability during root canal preparation.

Keywords: Canal Transportation; Centering Ability; Cone Beam Computed Tomography; One Curve; Pro Taper Next

Abbreviation

CBCT: Cone Beam Computerized Tomography; OC: One Curve; PTN: Protaper Next; NaOCl: Sodium Hypochlorite; MD: Mesiodistal

Introduction

Cleaning, Shaping and appropriate sealing of the canals are the key of a successful root canal treatment. To fulfill the goals of endodontic treatment, we should always preserve the original shape of the canals and their optimal form. This can be achieved by developing a continuous tapered preparation from crown to tooth's apex and conserving the apical foramen's original spatial relationship to the periapical tissues and root surface. Elimination of bacterial biofilms and dentinal debris which are responsible for endodontic pathosis are also an important factor to be achieved [1,2].

Nevertheless, complex anatomy and curvatures of root canal systems and the inherent limitations of the enlarging instruments make the root canal treatment challenging and difficult. Instruments may fail to preserve the canal anatomy and lead to some iatrogenic errors such as ledges, perforations and canal transportation specially in curved root canals [3].

The introduction of various nickel-titanium instruments simplified and accelerated the root canal mechanical preparation. They have shown enhancement in mechanical properties as super elasticity, shape memory, and higher cutting efficiency to maintain the original shapes of the canals. This caused a limitation in mishaps compared with traditional stiff stainless steel hand instruments [4]. Since 1990s, NiTi rotary instruments had undergone different variations in terms of the methods of fabrication and their physical characteristics. Improvements have been made on the shape, design, and number of instruments used. The purpose of modifications is to develop a NiTi rotary instrument which cuts the dentin effectively and to enhance fracture resistance even in most challenging curved and narrow canals. Also, to simplify the cleaning and shaping phase and limit the number of instruments used while sustaining the original shape of the canals [5].

In the last decade, shaping of the root canals with single-file systems operated in rotary or reciprocating motion was introduced. The concept behind instrumentation with a single file is to achieve faster mechanical preparation with limited number of instruments inside the canal. Thus, the risk of file separation is reduced, and any possible cross contamination is prohibited [6,7].

One curve (Micro Mega, Besancon, France) is a single file system which was introduced in 2017 and manufactured from C-Wire NiTi by using proprietary heat treatment. It has a variable cross-section combined with continuous rotation movement to ensure excellent cutting efficiency and a perfect centering trajectory [8].

While Protaper Next (PTN; Dentsply Maillefer, Ballaigues, Switzerland) files are made from M-Wire, and have a unique off-centered rectangular cross section, which generates a mechanical wave of motion like a snake swaggering motion and provides a better reduction of the engagement between the file and dentin [9].

Up till now, there have been very few studies regarding the shaping ability in terms of canal transportation and centering ability of the One Curve single-file system. Thus, the present study was conducted to investigate the shaping ability of One Curve single file in curved canals compared to multiple files ProTaper Next rotary system using CBCT.

Materials and Methods

Sample size

Based on a previous study by Deepak., *et al*. 2015 [10] and using power 80% and 5% significance level we needed to study 15 teeth in each group.

Sample selection

A total of thirty extracted human mandibular molars that were extracted for different reasons and collected from the department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Cairo University. Inclusion criteria were the presence of two separate canals in the mesial root with two separate orifices and apices, patency achieved by a #10-15 K-file to the apical foramen, curvatures of mesiobuccal canal between 20° and 45°, mature apices and apical foramina, no root resorption, no calcification in the root canal, and no signs of cracks or fracture.

Sample preparation

The mesial root of each tooth was checked radiographically to ensure the curvature of mesiobuccal canal within the range of (20°- 45°) using the Digimizer Image analysis software (MedCalc Software bvba, Belgium) according to Schneider's method. All teeth were flattened at the coronal portion using a wheel stone high-speed handpiece (Dentsply, Sirona, Ballaigues, Switzerland) to ensure standardization of teeth length at 16 mm. Distal root and crown of each sample were sectioned at the furcation level with a diamond stone while coolant was applied. K-file (Dentsply Maillefer, Ballaigues, Switzerland) size #10 was inserted in each mesiobuccal canal to check patency. Samples were allocated randomly into two equal groups (15 samples each) according to the instrument used in the preparation of root canal (One Curve single file rotary system and Protaper Next system). Each group's samples were mounted vertically midway in transparent auto-polymerizing acrylic resin (Acrostone, Dental and Medical Supplies, Cairo, Egypt) prepared according to the manufacturer's instructions in two identical plastic moulds (10 cm x 12 cm x 2.5 cm); one mould for each group**.** Vaseline (Unilever, Indea) was used as a separating medium to paint the internal surface of the mould. Wax (Cavex, Haarlem, Netherlands) was used to seal the root apices to prevent resin from penetration through the apical foramen. Each sample was positioned in the unset acrylic resin where its long axis was parallel to the long axis of the mould, and with the buccal surfaces of all samples facing the same direction. Also, an amalgam filling was added into the resin at one corner of the mould facing the buccal surfaces of the root as a radiopaque index.

Pre-instrumentation scanning

All roots were scanned using cone beam computed tomography (Planmeca, Promax 3D classic, Helsinki, Finland) to detect canal shape before instrumentation. Exposure parameters were 85 kV and 8 mA. The field of view was 8 cm in diameter and 11 cm in height.

Root canal preparation

Samples were randomly divided into two equal groups (n =15 canals per group) as follows

- **OC group**: where roots were mechanically prepared using one single file (25/06) to the full working length. File was operated at 300 rpm/2.5 Ncm torque in continuous rotation motion.

- **PTN group**: where roots were mechanically prepared using, ProTaper Next X1 (17/04) and X2 (25/06) files to the full working length. Files were operated at 300 rpm/5 Ncm torque in continuous rotation motion.

Following the manufacturer's instructions for each system, E-connect S endo-motor (Eighteeth, Xuejia, China) was used for root canal preparation of all samples. Pre-Flaring of the mesio-buccal canals for all teeth was done using SX file (.19/.04) of ProTaper Gold system (Dentsply Sirona, Ballaigues, Switzerland); at speed 300 rpm, torque 5 N.cm, to enlarge the coronal section of the canals. The working length was determined 1 mm shorter than the root apex (15mm). The root canal preparation was then carried out using either One curve system or the ProTaper Next system, depending on the grouping of the samples. In both groups, irrigation of the canals was done using 5 ml of freshly prepared 2.6% sodium hypochlorite solution (Clorox, Cairo, Egypt) as an irrigant between each instrument using a 30-gauge side-vented needle (Elephant Dent, Hong Kong) in a plastic syringe placed as apical as possible into the canal without binding. MD-ChelCream was used for instrument lubrication. A #10 K-file was used between each rotary file to retain apical patency. Each file was removed from the canal and cleaned after three gentle in-and-out pecking motion strokes in an apical orientation. This procedure was done repeatedly until the WL was achieved. Each instrument of One curve or Protaper Next was used to prepare four canals only, then discarded.

Post-instrumentation scanning

CBCT was used to scan the root canals after mechanical preparation, comparable to the pre-instrumentation scanning routine.

Pre- and post- instrumentation measurements

Three tomograms were chosen for each sample based on their distance from the root apex, as follows: 8 mm from the root apex (representing the coronal third), 5 mm from the root apex (representing the middle third), and 3 mm from the root apex (representing the apical third). All scans were evaluated using the OnDemand 3D software (Cybermed Inc, Irvine, CA). In the axial plane, dentin thickness was measured mesially and distally from the root canal boundary to the root surface boundary for each tomogram (Figure 1).

Figure 1: Showing the pre- and post- instrumentation measurements of the dentine thickness at 3 mm level (apical third) in a selected sample.

The previously described software application was used to superimpose pre- and post-instrumentation scans to evaluate the degree of transportation and the centering ability of the tested instruments.

Evaluation method

Centering ability

Canal Centering refers to the ability of the instrument to remain centered in the canal. Canal centering was assessed at three predetermined levels (3, 5, and 8 mm) from the apex in the mesio-distal direction, using the method developed by Gambill., *et al.* (1996) [11] using the following formula

Mesio-distally

(M1-M2)/(D1-D2) or (D1-D2)/(M1-M2)

The formula was selected in such a manner that the lowest of the results acquired through the difference should be the numerator.

Where

- **M1**: refers to the shortest distance from the mesial edge of the root to the mesial edge of the un-instrumented canal.
- **M2**: refers to the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal.
- **D1**: refers to the shortest distance from the distal edge of the root to the distal edge of the un-instrumented canal.
- **D2**: refers to the shortest distance from the distal edge of the root to the distal edge of the instrumented canal

If the result of formula equals one, this will indicate that the rotary file remained centered (perfect centering ability), while if the result is less than one, this will indicate less centering ability (i.e., less ability of the instrument to stay centralized inside the canal).

Canal transportation

The degree of canal transportation was determined using the formula provided by Gambill., *et al*. (1996) [11]. The value used were the measurements of the shortest distance from the instrumented canal's edge to the root surface's periphery (mesially and distally) and comparing these measurements to the same measurements prior to canal instrumentation.

The formula used for calculation of canal transportation (CT)

Mesio-distal transportation

(M1-M2) - (D1-D2)
Where: M1, M2, D1 and D2 are the same as described before.

The result zero means no transportation, positive results indicated mesial transportation, and negative results indicated distal transportation.

Statistical analysis

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). All data showed non-normal (non-parametric) distribution. Non-parametric data were presented as median and range values. Mann-Whitney U test was used to compare between the two systems. Friedman's test was used to compare between different root levels. Dunn's test was used for pair-wise comparisons when Friedman's test is significant. Qualitative data (Direction of transportation) were presented as frequencies (n) and percentages (%). Fisher's Exact test was used to compare between the systems. The significance level was set at P ≤ 0.05. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

Results

Centering ability

There was no statistically significant difference between mesiodistal centric ratio (CR) at different root levels (apical, middle and coronal) within each system. (P-value =0.983 and 0.595 respectively). (Table 1).

There was no statistically significant difference between mesiodistal CR after using the two systems at three, five as well as eight millimeters root levels. (P-value = 0.640, 0.476 and 0.769 respectively). (Table 1).

As regards overall CR regardless of root level; there was also no statistically significant difference between the two systems. (P-value = 0.372). (Table 1).

Root level	ProTaper Next (n = 15)		One Curve (n = 15)		P-value	Effect size (d)
	Median	Range	Median	Range		
3 mm	0.6	0.33 - 1	0.6	0 - 1	0.640	0.167
5 mm	0.5	0.25 - 1	0.5	0.25 - 1	0.476	0.26
8 mm	0.5	0.08 - 1	0.5	0.2 - 1	0.769	0.106
P-value	0.983		0.595			
Effect size (w)	0.001		0.035			
Overall	0.62	0.47 - 0.9	0.55	0.36 - 0.83	0.372	0.33

Table 1: The median, range values and results of Mann-Whiney U test for comparison between CR in the mesiodistal direction after using the two systems and Friedman's test for comparison between different root levels.

***:** Significant at P ≤ 0.05.

Canal transportation

Amount of canal transportation

There was no statistically significant difference between amounts of mesio-distal canal transportation at different root levels (apical, middle, coronal) within each system. (*P*-value = 0.464 and 0.171 respectively). (Table 2).

There was no statistically significant difference between amounts of MD canal transportation after using the two systems; Group 1: One Curve and Group 2: ProTaper Next (PTN) at three, five as well as eight millimeters root levels. (*P*-value = 0.669, 0.684 and 0.832 respectively). (Table 2).

Root level	ProTaper Next (n = 15)		One Curve (n = 15)		P-value	Effect size (d)
	Median	Range	Median	Range		
3 mm	0.1	0 - 0.3	0.1	0 - 0.4	0.669	0.152
5 mm	0.2	0.1 - 1	0.2	0 - 0.4	0.684	0.144
8 mm	0.2	0 - 1.1	0.2	0 - 0.7	0.832	0.076
P-value	0.464		0.171			
Effect size (w)	0.051		0.118			
Overall	0.17	0.1 - 0.47	0.17	0.07 - 0.4	0.489	0.252

Table 2: The median, range values and results of Mann-Whiney U test for comparison between amounts of canal transportation (mm) in the Mesiodistal direction after using the two systems and Friedman's test for comparison between different root levels.

***:** Significant at P ≤ 0.05.

As regards overall amount of MD canal transportation regardless of root level; there was also no statistically significant difference between the two systems. (P-value = 0.489). (Table 2).

Direction of transportation

There was no statistically significant difference between directions of mesiodistal canal transportation after using the two systems at all root levels (3,5,8 mm). (*P*-value = 0.520, 0.613 and 0.634 respectively). (Table 3).

Root level	Direction	ProTaper Next (n = 15)		One Curve (n = 15)		*P*-value	Effect size (v)
		n	%	n	%		
3 mm	No transportation	4	26.7	6	40	0.520	0.242
	Mesial	6	40	7	46.7		
	Distal	5	33.3	2	13.3		
5 mm	No transportation	0	0	2	13.3	0.613	0.274
	Mesial	6	40	6	40		
	Distal	9	60	7	46.7		
8 mm	No transportation	4	26.7	3	20	0.634	0.204
	Mesial	6	40	9	60		
	Distal	5	33.3	3	20		

Table 3: The frequencies (n), percentages (%) and results of Fisher's Exact test for comparison between directions of MD transportation after using the two systems.

***:** Significant at P ≤ 0.05.

Discussion

The present study was conducted to compare the centering ability and canal transportation of One Curve single file and Protaper Next files system in the mesiobuccal root canals of mandibular molars using CBCT.

This study was designated to be a comparative *in vitro* study to allow control the variables and uniformity of the results. One curve single file system (Micro Mega, Besancon, France) has been introduced to the market in the recent years, manufactured from C-Wire heat-treated NiTi material with controlled memory property where the shape of the file can be flexibly modified to allow easier access while respecting canal's anatomy [8,12]. The concept of using single file system is gaining nowadays clinical acceptance as it simplifies instrumentation protocols in comparison to multiple-files system, reduces the chairside working time, limits the number of failures related to instrumentation, in addition its more cost- effective and avoid the risk of cross contamination [13,14].

While ProTaper Next (PTN; Dentsply Maillefer, Ballaigues, Switzerland) is a multi-file system with an off-centered rectangular cross-section and is made of M-wire NiTi alloy, which increases file flexibility and cyclic fatigue resistance [15]. This system was selected as a comparator in this study and can be considered as a reference for comparison as it has been used over years successfully [13,16,17].

Extracted mandibular human first molars were used in the present study as experimental model to study the actual performance of instrument on natural dentin and to replicate realistic clinical conditions encountered by practitioners in comparison to resin blocks with simulated canals. Although the artificial root canals have advantages of standardization and reproducibility, yet they show limitations as they cannot mimic the real texture, hardness and stiffness of dentin, nor the detailed anatomical features of natural canals and the possible side effect of softening the resin material created by heat generated during instrumentation which may cause binding of the cutting blades of instruments [18-20]. Mesio-buccal root canals were chosen from extracted human mandibular molars in agreement with several previous studies. These canals are prone to iatrogenic errors, they often present specific anatomical features as they are often narrow, and also show variations of curvatures in mesio-distal and bucco-lingual planes [21-23].

Specimens included in this study possessed similar preoperative geometric characters to ensure standardization, samples were adjusted to 16 mm length, the apical canal diameter was also standardized to size #10 k files [24], and the angle of curvature of the canals within a range of (20°- 45°) measured using *Schneider's* method; which is accurate, simple and reliable [25]. The range of radius was (r > 4 and r ≤10 mm) according to *Pruett*'s method which is a moderate curvature [26]. The apices of mesial roots were sealed with wax balls to avoid the flow of the resin inside the canals and impair their patency.

To achieve standardization during tomographic scanning, samples were inserted in the unset acrylic resin with their buccal surfaces facing the same direction and their long axis parallel to the long axis of the mold [16]. Furthermore, inserting an amalgam filling into the resin at the mold's corner, facing the buccal surfaces of the roots; this assists in canal orientation during scanning [27].

When comparing the shaping abilities of different root canal tools, it is essential to standardize the tip size of the final file utilized to achieve the same diameter of apical preparation [28]. For this reason, One Curve single file and ProTaper Next X2 were employed as final files in the single-file and multi-file systems, to standardize canal preparation to a size 25 final shape.

Irrigant of choice used during instrumentation was 2.6% Sodium hypochlorite (NaOCl) due to its antibacterial characteristic, also helps in dissolving tissue and lubrication. This concentration is the most commonly used during endodontic treatment as it was showed balance between the anti-bacterial effect and cytotoxicity [29,30]. A needle with a 30-gauge tip was inserted 1-2 mm shorter than the working length to permit deep insertion of the (NaOCl) irrigant to the apical third [31]. All specimens were prepared with the aid of EDTA as a lubricant.

Pre-flaring of mesiobuccal canals of all teeth was done using SX file (.19/.04) of ProTaper Gold system; which guarantees that the canal diameter is enlarged sufficiently to allow safer use of the first shaping instrument. As a result, the files have a practically direct pathway to the apical end of the canal, while the danger of file fracture is reduced and any coronal resistance is limited [32,33].

In this study, cone beam computed tomography imaging was suggested to evaluate root canal shaping. CBCT is a non-invasive and precise method, which provides reproducible, accurate, reliable and detailed three-dimensional (3D) images without any teeth destruction. Using CBCT allows better visualization of the anatomy and better pre-operative and post-operative assessment of any morphological changes in the canal's trajectory [34,35].

Canal transportation is a term that refers to the removal of extra dentine in a specific direction rather than equally in all canal directions, due to the file tendency to restore its original straight shape during curved canal preparation, this will cause a high risk of straightening the original curvature of the canals and forming ledges in the wall [36,37]. The clinical consequence of transportation will jeopardize root canal sealing and thus reducing the treatment outcomes [38]. While, centering ability refers to the capability of the instrument axis to remain in-line with the canal axis. The value equals to one indicates perfect centering [39]. A formula given by Gambill., *et al.* 1996 was used to calculate canal transportation and centering ability [11].

Outcomes in this study were assessed at three different levels; 3, 5, and 8 mm from the root apex [40]; where 3mm represent the apical third where at this particular level apical transportation and zips were frequently found to occur [36,41], 5 mm and 8 mm represents the middle and the coronal third respectively; they are prone to stripping especially distally where dangerous zone exists [36,42].

During canal instrumentation, it's important to remove infected dentin and produce an adequate space for irrigation and obturation [43]. It has been found that apical transportation greater than 0.3 mm reduces the impermeability of the filling material of the canal, compromising the apical seal and jeopardizing the outcome of endodontic therapy [44].

Regarding the centering ability, there was no statistically significant difference between the tested groups mesiodistally at any root level (P > 0.05). The ProTaper Next was slightly more centered. The results obtained in this study are in agreement with the findings of previous reports of Vyver., *et al*. (2019) [32], Razcha., *et al.* (2020) [19] and Kolhe., *et al*. (2020) [45].

Both of ProTaper Next and One Curve files can be credited to their asymmetrical cross-section design. Their snake-like motion preserves the canal's natural anatomy due to the offset rotating center, which allows the file to engage and disengage along the canal walls, eliminating stresses between the file and the canal wall and resulting in greater centering ability. As well as the files flexibility which also improved centralization during root canal preparation.

In spite of that the two systems had different metallurgical properties in their NiTi alloys, yet this didn't influence the performance regarding canal transportation and centering ability. Staffoli., *et al.* (2018) [46] stated that thermomechanical treatment of the NiTi alloy didn't impact the performance in terms of transportation and centering ability.

Regarding the canal transportation, there was no statistically significant difference between the two examined groups in terms of mesio-distal transportation at the apical, middle, and coronal thirds (P > 0.05), and at the 3 mm level, the canal transportation value was less than the critical canal transportation value of 0.3 mm.

The results were in accordance with Gomaa., *et al.* (2021) [47] who reported that at the apical third, canal terminus and coronal curvature, One Curve file with controlled memory property resulted in less transportation than the PTN files with super-elastic properties. As well as Tufenkci., *et al*. (2020) [48] who stated that at the apical zone One Curve file system yielded less transportation than the ProTaper Next.

Concerning the direction of transportation, One Curve single file and Protaper Next system revealed no statistically significant difference among all the root levels, in all dimensions (P > 0.05). Mesio-distally, both instruments showed a higher tendency toward mesial transportation apically, distal transportation in the middle third, and mesial transportation coronally. It has been suggested that aggressive instrumentation in the cervical third of the canal may be the cause of strip perforations, which may lead to inflammatory complications [49]. Accordingly, the less tendency towards distal transportation coronally, the more favorable feature for both of the instruments.

Generally, there are numerous instrument-related factors that usually influence the shaping ability of the canals including; instrument design (cross sectional designs, taper degree, radial lands, tip design), metallurgy of NiTi alloy of the systems, movement kinematics and instrumentation technique (creation of glide path, coronal pre-flaring and size of apical preparation). The insignificant difference regarding most of the aspects of the shaping ability among the two groups could be clarified by the several similarities between them including coronal pre-flaring (ProTaper Gold SX file), movement kinematics (rotational), tip design (modified non-cutting tips), instrumentation technique (crown-down technique) and the apical preparation size (size 25,0.06 taper).

Conclusion

Within the limitations of this *in vitro* study, it can be concluded that

- Preparation of curved mesio-buccal root canals using One Curve and ProTaper Next systems was relatively safe.
- Both systems showed comparable performance regarding the degree of canal transportation and centering ability.

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Conflict of Interest

I declare that this thesis has been composed solely by myself and there is no conflict of interest.

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