

Comparison of Centering Ability of Three Different Endodontic Instruments Using Cone-beam Computed Tomography: An *In Vitro* Study

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ABSTRACT

Aim: Centering ability of an instrument is the ability of the instrument to act centrally inside the canal without deflections. This property is of significance in assessment of any endodontic file because endodontic accidents due to instrumentation, commonly apical transportation can be avoided in case of a perfectly centered instrument. Therefore, the aim of the present study was to compare three different endodontic files, K File, Hand ProTaper, and Rotary ProTaper for their centering ability using cone-beam computed tomography (CBCT).

Materials and methods: On 30 extracted mandibular premolars, 3 reference lines were created from the apex. Preoperative CBCT images were made and analyzed. D_1 and D_2 are the centering ratios measured buccolingually and mesiodistally, following which the samples were randomly allotted to one of the three groups (K File, Hand ProTaper, and Rotary ProTaper) for instrumentation. Postoperative images were obtained and canal dimensions were assessed. The differences were calculated and the centering ability was determined using the centering ratio formula. Comparison was done using ANOVA test.

Results: The mean working length of all the samples was 20.8 mm. The average preoperative D_1 and D_2 values obtained were 0.0067 and 0.0117, respectively. Following instrumentation, the obtained D_1 and D_2 values in group I, group II, and group III were 0.0048 and 1.07, 0.783 and 1.24, and 0.785 and 0.96, respectively. Intergroup comparison showed insignificant p value ($p > 0.05$).

Conclusion: K File, Hand ProTaper, and Rotary ProTaper were equally efficient to act centrally in straight canals.

Clinical significance: Centering ability of an instrument is of significance in avoiding accidents such as canal transportation. K File, Hand ProTaper, and Rotary ProTaper were found to be equally efficient to act centrally in straight canals.

Keywords: Canal preparation, Centering, Cone-beam computed tomography, Root canal therapy.

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INTRODUCTION

The step of canal shaping in the endodontic treatment is very pivotal as it is critical for canal irrigation and obturation, thereby influencing the overall success of the treatment.¹ The objective of canal shaping is to create a continuous tapered preparation from crown to apex while maintaining the original path of the canal and keeping the foramen size as small as practical.² This is called as the centering ability of an endodontic instrument where there is no or minimum deviation of the canal from its original curvature or in other words the ability of an instrument to remain centered in the root canal system.

Thus, the centering ability of the files is an expected ideal property of all the endodontic instruments used for canal shaping. Centering ratio is described as the measurement of the ability of the instrument to stay centered in the canal, thus reducing the incidents of canal transportation.³

Other than clinical guidelines, no much literature support exists about the centering ability of commonly used endodontic instruments.

Thus, the aim of the present study was to compare the centering ability of three endodontic file systems—K Files, Hand ProTaper, and Rotary ProTaper files using cone-beam computed tomography (CBCT) in straight canal. The null hypothesis was set and there is no difference in centering ability among K Files, Hand ProTaper, and Rotary ProTaper.

MATERIALS AND METHODS

The present *in vitro* study was initiated after obtaining ethical clearance from the Institutional Ethics Committee. Freshly extracted

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30 mandibular premolars for orthodontic reasons were used in this study. Each included tooth had single root canal with closed apex. Teeth with calcified canals, curved canals, developmental anomalies, and multiple root canals were excluded. The teeth were divided among three groups using a simple randomization method as follows: group I—K Files (Dentsply, India 25 mm), group II—Hand ProTaper (Dentsply Protaper Universal Hand Files, 25 mm), and group III—Rotary ProTaper (Dentsply Rotary ProTaper NITI Files, 25 mm).

Preshaping Preparation of the Samples and CBCT Analyzes

In each tooth, three reference lines were created to standardize the plane of measurements done in pre- and posttreatment radiographs for comparison. Markings were done at three levels—3 mm (apical), 6 mm (middle), and 9 mm (coronal) from the apex using a tapered fissured bur which were then filled with a composite resin restorative material (3M ESPE Filtek™ Z250 XT, USA) (Fig. 1).

Access opening was done using a medium grade round bur and endo access bur at high speed. The canals were explored using #10 K File and radiographically working length determined using #15 K File. The teeth were then subjected to CBCT for initial assessment, following which the teeth were instrumented.

Canal Shaping

Group I were hand instrumented using stainless steel K Files. After the enlargement of the coronal third of the teeth using gates glidden drill, the apical preparation was done till #35 file and crown down preparation was done up to #50 file. Hand ProTaper and Rotary ProTaper nickel titanium (NiTi) files were used for biomechanical preparation in groups II and III, respectively. In both the groups of ProTaper files, initially SX file was used for coronal shaping with almost half the working length, followed by use of S1 till 4 mm short of working length, and S1 and S2 up to the apex. Finally, F1 and F2 were used up to the apex for finishing.

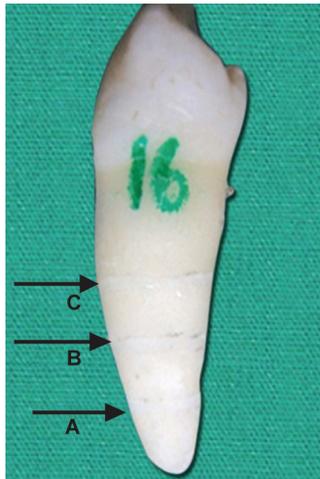
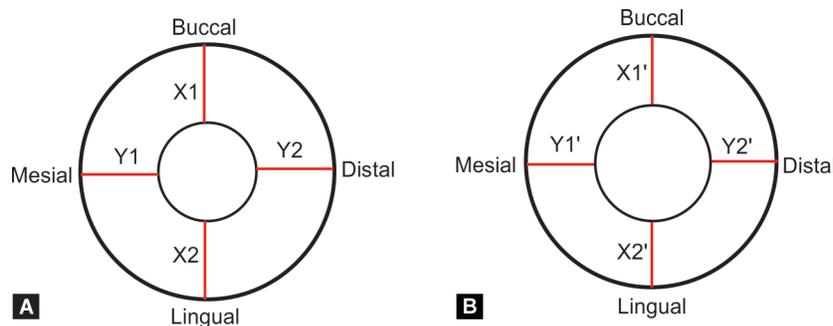


Fig. 1: Marking and scoring of the reference line. (A) 3 mm from apex; (B) 6 mm from apex; (C) 9 mm from apex



Figs. 2A and B: Diagrammatic representation of the measurements from external tooth surface. (A) Preoperative; (B) Postoperative

In all the groups, during instrumentation, the samples were irrigated using a disposable beveled irrigation needle (Precision Glide Needle; Becton Dickinson & Co., Franklin Lakes, NJ).⁴ The irrigation cycle included delivery of 0.6 mL of 5.25% NaOCl and 15% EDTA, within 4 mm of working length measured for about 20 seconds. This is followed by agitation of solution with a #25 Flexofile. The irrigation was repeated for 5 times until 3.0 mL of the solution was utilized. Finally, 1.2 mL of saline was used to wash out the solution completely.⁵ The canals were dried using paper points and CBCT images were obtained.

Evaluation of Centering Ability

Image analysis was done using CS 3D Imaging Software 3.2.9 (Carestream Health Inc.) by a single blinded operator. The radio-opaque reference lines were used for image slicing and analysis. Distance from the canal and outer surface of the tooth were measured at four aspects (buccal, mesial, distal, and lingual) and at three levels (Fig. 2).

Preoperative measurements from the external surface to the canal were X1, X2, Y1, and Y2—buccal, lingual, mesial, and distal, respectively. Postoperative measurements from the external surface to the canal were X1', X2', Y1', and Y2'—buccal, lingual, mesial, and distal, respectively.

The obtained preoperative and postoperative images with measurements were subjected to centering ratio formula as given by Gambill et al.³

$$D_1 = (X1 - X1') / (X2 - X2')$$

$$D_2 = (Y1 - Y1') / (Y2 - Y2')$$

where D_1 denotes the buccolingual measurement and D_2 denotes the mesiodistal measurement. The values were coded as 0 and 1, where 1 indicates a perfect centering ability and the values toward 0 indicate poor centering ability. D_1 and D_2 values of all the samples at three reference lines were measured.

Statistical Analysis

The obtained data were compiled systematically. Statistical data were analyzed using SPSS for Windows release 20.0 (SPSS Inc., Chicago, IL, USA).

Repeated measures ANOVA test was used to compare the three groups. Intergroup comparison was made using *post hoc* test (Tukey HSD). Level of significance was set at 0.05.

RESULTS

The mean working length was 20.8 mm. The average precanal shaping D_1 and D_2 values obtained in the present study were 0.0067

Table 1: Frequency occurrence of the D_1 and D_2 values in three groups

Groups	Section	D_1		D_2	
		0	1	0	1
Group I (K File)	Apical	5	4	2	6
	Middle	4	3	2	7
	Coronal	4	5	1	6
Group II (Hand ProTaper)	Apical	1	7	2	7
	Middle	1	6	2	6
	Coronal	3	6	3	6
Group III (Rotary ProTaper)	Apical	1	8	0	9
	Middle	0	10	3	6
	Coronal	1	8	0	9

Table 2: Inter- and intragroup comparison of D_1 and D_2 values

Factor	Df	Mean square	p value
File	2	0.373	0.381
File * section	4	0.610	0.183

Table 3: Intergroup comparison for D_1 and D_2 values

File system	Comparison group	Mean difference	Standard error	p value
K File	Hand ProTaper	-0.1033	0.05634	0.165
Hand ProTaper	Rotary ProTaper	0.0142	0.05634	0.966
Rotary ProTaper	K File	0.0892	0.05634	0.259

and 0.0117, respectively. The average D_1 and D_2 values obtained in group I after canal shaping were 0.0048 and 1.07, respectively. Postcanal shaping D_1 and D_2 values in group II were 0.783 and 1.24, respectively, whereas the same of group III were 0.785 and 0.96, respectively.

The frequency of occurrence of the values 0 and 1 in 3 groups are tabulated in Table 1. K File group had total of 18 values toward 0 and 31 values toward 1. Hand ProTaper group had 12 values toward 0 and 38 values toward 1, whereas group III had only 5 values toward 0 and 50 values toward 1.

Table 2 shows the results of repeated measures of ANOVA considering the files and the sections as factors of consideration. The results are not significant with $p > 0.05$.

Intergroup comparison (Table 3) was made using *post hoc* test (Tukey HSD). The obtained values with 95% confidence interval suggest insignificant difference between the groups ($p > 0.05$).

DISCUSSION

Root canal therapy involves cleaning and shaping of the canals with the primary goal to eliminate the infected tissues and provide a tight seal during obturation. The biomechanical preparation is performed using sterile endodontic files. Various endodontic instruments are available for instrumentation during root canal treatment. The nickel titanium instruments introduced in the past decade remains popular in the endodontic treatment procedures.⁶

Teeth with fully formed apices were selected as conventional root canal therapy could not be possible in case of teeth with open apex. All the teeth were examined using dental loupes to ensure the complete root formation before initiating the study. Teeth extracted for prosthodontic reasons in elderly patients were excluded as aging is one of the factors for root canal calcification,

thus making it difficult for canal negotiation. Thus to standardize the instrumentation procedures, teeth with curved canals, pathologic root resorption were also excluded.^{7,8}

Three reference lines were created on the root surface of the samples at 3 mm, 6 mm, and 9 mm from the apex. These lines were used as indicators for the level of sectioning during the image analysis using CBCT. The teeth exhibits mild tendency to curve at the apex. Hence, the reference line was taken 3 mm from the apex. Nine millimeter from apex being the coronal reference line and exactly between these two lines at 6 mm from apex were considered for image analysis. The methodology used in the present study was based on the study by Sanfelice et al.⁹ which showed it to be reliable and sectioning of the specimens can be obtained without loss of tooth and thus can be used in clinical practice.

Centering ability can be evaluated using different methods such as CBCT, micro-CT, spiral CT, stereomicroscopic magnifier, and digital camera with superimposed images, etc.¹⁰ The easiest and efficient method of measuring centering ability is by determining the centering ratio as given by Gambill et al.³

Endodontic instruments have the tendency to deviate the prepared canal away from its original axis.¹¹

Introduction of NiTi files has revolutionized the procedure of canal shaping.¹ These instruments are superelastic and they flex far more than stainless steel instruments before exceeding their elastic limits.¹² ProTaper files are one such NiTi endodontic file systems that are available in 2 forms—hand and rotary. They have a modified cross-sectional design that resembles a K File configuration.² Though elective cutting efficiency of ProTaper files reduces torsional loads, their aggressive cutting property can increase canal transportation.¹³ ProTaper files have advantages such as increased flexibility and cutting efficiency. The cutting efficiency increases due to the triangular cross section of the instrument. Each instrument creates its own crown-down effect and the larger conicity creates space for the smaller ones thus maintaining the canal curvature with a small risk of apical transportation.²

The risk for apical transportation and certain endodontic procedural errors during instrumentation can be significantly reduced if the instrument has a perfect centering ability.¹⁴ Deviation from the original curvature of the canal can also lead to excessive dentin removal on one side, creation of a ledge in the dentinal wall, and canals with hourglass appearance cross-sectionally, etc.¹

The CBCT images were obtained in three orthogonal planes: axial plane, coronal plane, and sagittal plane. Aguiar et al.¹⁵ also used the same methodology in their study. The advantages of CBCT include three-dimensional rendition, geometrically precise images, patient comfort, extraoral placement of film or sensor.¹⁶

A number of studies on both extracted teeth and simulated canals have shown that rotary Ni-Ti instruments allow more rapid, more centered canal preparations than stainless steel instruments.¹⁷⁻¹⁹

ProTaper files are said to have increased flexibility and cutting efficiency due to its triangular cross section but have shown to have more canal transposition or low centering ability.²

In the present study, mandibular premolars with straight canals were selected. The samples collected were examined using dental loupes to ensure the complete root formation before initiating the study. The average working length of mandibular premolars used in our study was 20.8 mm. This value was close to the average lower premolar length of 21.2 mm.¹⁹

K Files are commonly used among the practitioners followed by the ProTaper NiTi files for endodontic procedures.²⁰ Hence, in the present study, ProTaper files were compared with the K Files.

The results of the present study showed that there was no significant difference in the centering ability of all three groups, thus accepting the null hypothesis. But there are numerous studies in the literature suggesting that NiTi instruments show better centering ability when compared with other instrument systems especially in a curved canal.^{8,21-25}

Limitation of the present study was that the canal shape, volume, and curvature change posttreatment, and risk of canal transportation could not be analyzed. In the present study, we have included only the teeth with straight canals and restricted to only three file systems. Further research should be done on curved canals utilizing other newer file systems.

CONCLUSION

Within the limitations of the present study, it can be concluded that K File, Hand ProTaper, and Rotary ProTaper were equally efficacious to act centrally in straight canals.

CLINICAL RELEVANCE

Centering ability of an instrument is of significance in avoiding accidents such as canal transportation. K File, Hand ProTaper, and Rotary ProTaper were found to be equally efficient to act centrally in straight canals.

AUTHOR CONTRIBUTION

All the authors contributed equally to this work.

REFERENCES

- Kandaswamy D, Venkateshbabu N, Porkodi I, et al. Canal-centering ability: An endodontic challenge. *J Conserv Dent* 2009;12(1):3-9. DOI: 10.4103/0972-0707.53334.
- Tambe VH, Nagmode PS, Abraham S, et al. Comparison of canal transportation and centering ability of rotary protaper, one shape system and wave one system using cone beam computed tomography: An *in vitro* study. *J Conserv Dent* 2014;17(6):561-565. DOI: 10.4103/0972-0707.144605.
- Gambill JM, Alder M, del Rio CE. Comparison of nickel-titanium and stainless steel hand-file instrumentation using computed tomography. *J Endod* 1996;22(7):369-375. DOI: 10.1016/S0099-2399(96)80221-4.
- Boutsoukis C, Verhaagen B, Versluis M, et al. Evaluation of irrigant flow in the root canal using different needle types by an unsteady computational fluid dynamics model. *J Endod* 2010;36(5):875-879. DOI: 10.1016/j.joen.2009.12.026.
- Sobhani OE, Gulabivala K, Knowles JC, et al. The effect of irrigation time, root morphology and dentine thickness on tooth surface strain when using 5% sodium hypochlorite and 17% EDTA. *Int Endod J* 2010;43(3):190-199. DOI: 10.1111/j.1365-2591.2009.01655.x.
- Lopes DS, Pessoa MA, Aguiar CM. Assessment of the Centralization of Root Canal Preparation with Rotary Systems. *Acta Stomatol Croat* 2016;50(3):242-250. DOI: 10.15644/asc50/3/7.
- Yang YM, Guo B, Guo LY, et al. CBCT-Aided Microscopic and Ultrasonic Treatment for Upper or Middle Thirds Calcified Root Canals. *Biomed Res Int* 2016;2016:4793146. DOI: 10.1155/2016/4793146.
- McCabe PS, Dummer PMH. Pulp canal obliteration: an endodontic diagnosis and treatment challenge. *Int Endod J* 2012;45(2):177-197. DOI: 10.1111/j.1365-2591.2011.01963.x.
- Sanfelice CM, da Costa FB, S6 MVR, et al. Effects of four instruments on coronal pre-enlargement by using cone beam computed tomography. *J Endod* 2010;36:858-861. DOI: 10.1016/j.joen.2009.12.003.
- Gundappa M, Bansal R, Khoriya S, et al. Root canal centering ability of rotary cutting nickel titanium instruments: A meta-analysis. *J Conserv Dent* 2014;17:504-509. DOI: 10.4103/0972-0707.144567.
- Kishore A, Gurtu A, Bansal R, et al. Comparison of canal transportation and centering ability of Twisted Files, HyFlex controlled memory, and Wave One using computed tomography scan: An *in vitro* study. *J Conserv Dent* 2017;20(3):161-165. DOI: 10.4103/JCD.JCD_110_16.
- Walia HM, Brantley WA, Gerstein H. An initial investigation of the bending and torsional properties of nitinol root canal files. *J Endod* 1998;14:346-351. DOI: 10.1016/S0099-2399(88)80196-1.
- Maitin N, Arunagiri D, Brave D, et al. An *ex vivo* comparative analysis on shaping ability of four NiTi Rotary endodontic instrument using spiral computed tomography. *J Conserv Dent* 2013;16:219-223. DOI: 10.4103/0972-0707.111318.
- Paleker F, van der Vyver PJ. Comparison of Canal Transportation and Centering Ability of K-files, ProGlider File, and G-Files: A Micro-Computed Tomography Study of Curved Root Canals. *J Endod* 2016;42(7):1105-1109. DOI: 10.1016/j.joen.2016.04.005.
- Aguiar CM, Donida FA, Camara AC, et al. Changes in root canal anatomy using three nickel-titanium rotary system - A cone beam computed tomography analysis. *Braz J Oral Sci* 2013;12(4):307-312. DOI: 10.1590/S1677-32252013000400006.
- Durack C, Patel S. Cone beam computed tomography in endodontics. *Braz Dent J* 2012;23:179-191. DOI: 10.1590/S0103-64402012000300001.
- Glossen CR, Hiller RH, Dove B, et al. A comparison of root canal preparations using Ni-Ti hand, Ni-Ti engine-driven, and K-Flex endodontic instruments. *J Endod* 1995;21:146-151.
- Kum KY, Spångberg L, Cha BY, et al. Shaping ability of three ProFile rotary instrumentation techniques in simulated resin root canals. *J Endod* 2000;26:719-723.
- Jain A, Bahuguna R. Root canal morphology of mandibular first premolar in a gujarati population - an *in vitro* study. *Dent Res J* 2011;8(3):118-122.
- Pettiette MT, Metzger Z, Phillips C, et al. Endodontic complications of root canal therapy performed by dental students with stainless-steel K-files and nickel-titanium hand files. *J Endod* 1999;25(4):230-234. DOI: 10.1016/S0099-2399(99)80148-4.
- Swarnkar A. A Comparison of Canal-centering ability of Two Nickel-Titanium Rotary Systems with Nickel Hand Instrumentation with Stainless Steel Hand Instrumentation in 10 to 25° Curved Canals using Kuttler's Cube. *Int J Clin Pediatr Dent* 2014;7(3):157-162. DOI: 10.5005/jp-journals-10005-1256.
- Yun HH, Kim SK. A comparison of shaping abilities of 4 Ni-Ti rotary instruments in simulated root canals. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2003;95:228-233. DOI: 10.1067/moe.2003.92.
- Bergmans L, Van Cleynenbreugel J, Beullens M, et al. Progressive vs constant tapered shaft design using Ni-Ti rotary instruments. *Int Endod J* 2003;36:288-295. DOI: 10.1046/j.1365-2591.2003.00650.x.
- Miglani S, Gopikrishna V, Parameswaran A, et al. Canal centering ability of two Ni-Ti rotary systems compared with SS hand instrumentation in curved canals using Kuttler's endodontic cube-An *in vitro* study. *Endodontology* 2004;16:42-48.
- Guelzow A, Stamm O, Martus P, et al. Comparative study of six rotary Ni-Ti systems and hand instrumentation for root canal preparation. *Int Endod J* 2005;38:743-752. DOI: 10.1111/j.1365-2591.2005.01010.x.