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Comparative evaluation of centering ability of hand, rotary and reciprocating file systems using cone beam computed tomography: An *In vitro* study

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Abstract
It is important to develop a continuously tapered form and to maintain the Original shape and position of the apical foramen during instrumentation. The presence of curvatures may cause difficulty in root canal instrumentation. The ability to keep instruments centered is essential to provide a correct enlargement, without excessive weakening of the root structure. Several studies have shown that Ni-Ti instruments remain significantly more centered and demonstrated less canal transportation than stainless steel files. Considerable research has been undertaken to understand the several factors related to an instrument's canal-centering ability. The objective of this study was to evaluate and compare the centering ability of conventional Hand K files, Rotary Protaper next and Reciprocating Wave One gold systems using cone beam computed tomography.

Keywords: reciprocation, cone beam computed tomography, centering ability

1. Introduction
Root canal therapy involves the use of instruments and irrigants to shape and chemomechanically prepare the root canal system to receive a three-dimensional filling of the entire root canal space [1]. Canal-shaping is a critical aspect of endodontic treatment because it influences the outcome of the subsequent phases of canal irrigation, filling, and the overall success of the treatment itself. The goal of instrumentation is to produce a continuously tapered preparation that maintains the canal anatomy, keeping the foramen as small as possible [1] without any deviation from the original canal curvature [2]. The structural durability of the tooth following root canal therapy is based on the remaining tooth structure present. Aggressive instrumentation of root canal causes loss of dentin which may weaken the tooth.
Studies have shown that the preparation of curved root canals with stainless steel instruments frequently results in undesirable aberrations such as elbows, zips, and danger zones [1]. The introduction of Ni-Ti rotary instruments has not only enabled easier and faster instrumentation of the root canal system, but also has provided consistent, predictable and reproducible shaping with considerably less iatrogenic damage [2] Conventional stainless-steel hand instruments however were not sufficient to fulfil these objectives effectively [3, 5]. Canal shaping can be considered as one of the aims of the root canal instrumentation, which creates a tapered shape with sufficient volume that allows effective irrigation and obturation [6].
Super-elasticity of ni-ti alloys made it possible to stand out when compared to hand instruments [7]. Super-elastic property of the alloy allows the files to be better centered [7, 10] so that extremely curved canals can be shaped with less transportation [11, 12]. With time, many Ni - Ti instrument systems with different features have been introduced. One among them is protaper niti rotary instruments (Dentsply Maillefer, Switzerland), which has changing helical angle and pitch over the cutting blades and a noncutting, modified guiding tip [8]. The protaper NEXT (PTN) System the successor of Protaper provides shaping advantages through the convergence of a variable tapered design, innovative M-Wire technology, and a unique offset mass of rotation

2. Materials and methods
Roots with fully formed apices having angles of curvature within 0-20 degrees were included. Roots with developmental anomalies, calcification, internal and external resorption, canals that were larger than ISO size 20, length less than 13 mm fracture and teeth that showed signs of previous root canal treatment or attempts were excluded.
The Mesiobuccal roots of those teeth having angle of curvature between $0 - 20^0$ and a length of 13mm were selected. The angle of curvature was measured with the help of an RVG by Schneider's method.
The roots were then sectioned to a length of 13 mm using a diamond disc. To determine the working length, a size 10 K- File was inserted into the canal until it was visible at the apical foramen. The working length of each canal was calculated to be 1 mm less than the length obtained by the initial file.
The 36 roots were randomly divided into 3 groups (Instrumentation to be done with Hand Stainless steel K-Files, Rotary protaper Next files and Reciprocating waveone gold files respectively with 12 in each group.
Three custom made wax block simulated in the form of mandibular arch were fabricated for mounting twelve roots in each block. An ISO size 10 k files were inserted in the straight part of the canal (coronal third). The roots were mounted perpendicular to the base of the wax block and parallel to each other in terms of coronal 3rd of the roots which is the straight part of the canal using the mounted file as reference for parallelism. This is to ensure standardisation of access path of instrumentation.

2.1 Pre - instrumentation Scanning
The samples of all the three groups mounted in the wax block were scanned by CBCT to determine the root canal shape before instrumentation. The samples were scanned

using the scanner Kodak CS 9300 (Carestream Health Inc., NY, USA) operating at 90 kv, 10 mA with a FOV 5 cm x 5 cm, resolution 90 µm, and exposure time of 18.6 s along with CS 3D Imaging Software 3.3.11. The specimens were scanned in such a way that the beam passes perpendicular to the long axis of the specimens. Three sections from each tooth were selected. Three sections were selected for each root at 3mm (coronal), 6 mm (middle) and 9 mm apical from the coronal reference point.

After initial scans, root canals were instrumented by the same operator using a technique as per manufacturer's recommendations.

Group 1 – instrumented with hand k files of 2 % taper upto 30 size using step back technique. Patency is achieved with a 10 K file and shaping was commenced from number 15 K file and continued up to number 30 k file in a sequential manner. Recapitulation was done before every successive file usage.

Group 2 – instrumented with protaper next DENTSPLY starting from X1 (17/04%) taper file followed by X2 (25/06% taper) file upto X3 (30/7% taper) using 128:1 reduction geared hand piece powered by electric motor using rotary motion at a rotational speed of 350 rpm along with torque value of 200 g/cm.

Group 3 – instrumented with wave one gold system. The apical foramen was enlarged upto size 35 K stainless steel hand file. The waveone gold medium file (35 /7%) taper was introduced into the canal as per the manufacturer's recommendations using reciprocating motion.

After the use of each file, the flutes of the used instruments were cleaned using gauze soaked in 70% ethyl alcohol and canals were irrigated with 3 ml of a 5.25% naocl solution in all the groups. RC Help (Prime dental, India) was used as a lubricant during instrumentation, and after root canal instrumentation was completed, 1 ml of 17% ethylene diamine tetra-acetic acid was used for 1 min followed by a final flush of 3 ml of NaoCl. Fresh files were used in each and every sample. After instrumentation, the samples were subjected to CBCT scanning to obtain post instrumentation measurements under same condition and settings that was used for pre instrumentation.

Centering ability was calculated using the pre and post instrumented images.

The results were tabulated and statistical tests was applied.

3. Results

The canal centering ratio at each level was calculated using the formula:[7]

D1=(x-x')/(x1-x1') in the buccal-lingual direction and

D2=(z-z')/(z1-z1'), mesial-distal direction.

Where,

X and X1-shortest buccal and lingual distances of the un-instrumented canals respectively. Z and Z1 - shortest mesial and distal distance of the un-instrumented canals respectively.

X' and X1'- shortest buccal and lingual distances of the instrumented canals respectively.

Z' and Z1'- shortest mesial and distal distance of the instrumented canals respectively. (Figure – 1)

In the inter group comparison, the conventional Hand K files showed better centering ability at 3 mm (Mean = 1.005) in the buccolingual directions. The PTN files showed better centering ability at 9mm (Mean = 0.82) in the buccolingual directions. The WOG files showed better centering ability at 6 mm (Mean = 0.98) in the buccolingual directions. (Figure -2)

The comparison of the means of the centering ability of conventional Hand K Files, Rotary Protaper Next and reciprocating Waveone gold were not statistically significant in the buccolingual directions.

The comparative results between conventional Hand K files and PTN files showed that hand k files showed better centering ability at 3mm (mean = 1.005) whereas at 6 mm and 9 mm PTN files showed better centering ability (mean = 1.38 and 0.82 respectively) in the buccolingual directions.

The comparative results between conventional Hand K files and WOG files showed that hand k files showed better centering ability at 3mm (mean = 1.005) whereas at 6 mm and 9 mm WOG files showed better centering ability (mean = 0.98 and 1.16 respectively) in the buccolingual directions.

All statistical procedures were performed using Statistical Package for Social Sciences (SPSS) 20.0. Calculations for power (80%) of study will be performed before commencement of the study. Shapiro-Wilk test was used for testing the normality assumption of the data. Mann Whitney u test was used to find the association between different file systems. Probability value ($p < 0.05$) will be considered statistically significant.

4. Discussion

The above results can be attributed to the fact that the standard cutting tip and unyielding nature of the Stainless-steel files can be too aggressive because the first flute makes the initial cut in canal transportation, whereas the rotary system has a modified noncutting tip [9]. The noncutting tip that guides the blades of the instrument in the canal lumen could be the reason for Ni-Ti systems more centered than the standard K-files in the middle and the apical third [9]. Our results are in confirmation with the study by Gambill *et al*. and glossen *et al*. [7, 10]

The good centering ability of WOG may be attributed to three factors, one is the reciprocating motion of the file, as reciprocal motion suggested to make the preparation of file more centered.[11] Second is the technique of using just a single file as instructed by the manufacturer. This technique involves gradual introduction of the working length of the file, where the file probably reaches the full working length after the coronal part is partially prepared by a file. The third factor is the flexibility of WOG due to the thermal treatment. Flexibility of a file makes it follow the root canal anatomy without considerable resistance.

The comparative results between Conventional Hand K files, Rotary Protaper Next and Reciprocating Waveone gold was not statistically significant even in the mesiodistal directions. This might be attributed to the fact the files left untouched dentin in the mesiodistal direction due to the mesial curvature of the roots which is evident from the fact that the amount of dentin removal is more in the distal aspect of the curvature. This explains that there were more surfaces of untouched dentin in the mesial surface than the distal surfaces. This is in agreement with the results of a study where K-files created pronounced zips and elbows and removed an excessive amount of dentin from the outer aspect of the canal curves.[12]

The mean centering ability at 6mm of PTN in the Mesiodistal directions was 0.44 and 1.38 in the buccolingual direction which shows that PTN has a better centricity in the buccolingual direction at 6mm. The intragroup comparison

in the Protaper Next group showed that there was significant difference at 6 mm of the root canal P Value 0.02 (less than 0.05). This might be probably due to the taper of the instrument (protaper Next 0.07 %). In a study by Troiano *et al*, it has been supposed that "Instruments like PTN with an offset rotational mass may describe a larger envelope of motion than similarly sized files with symmetrical mass and axis of rotation" [16].

The main characteristic of the rotary Ni-Ti files is that the centre of the file mass is offset (off centre). This off-centredness was claimed to add some advantages to this file such as decreasing the engagement between the file and dentin, decreasing torque, and reducing the screw effect. Furthermore, it was thought to reduce the possibility of blocking the dentinal tubules by pushing debris laterally [13] and to enhance the ability to remove debris out of the root canal [14]. Additionally, the offset centre of the PTN file gives it an ability to prepare a size of canal that would otherwise require larger and stiffer files with a centred axis of rotation [11]. The progressively decreasing percentage tapered design that can be found in any protaper file is claimed to increase the flexibility of PTN files, limit the preparation to the body of the canal and conserve the coronal root canal structure [15].

Hence, within the limitations of the study Reciprocation Waveone gold Files system showed better centering ability at the middle (6 mm) and apical (9 mm) third of the root canals.

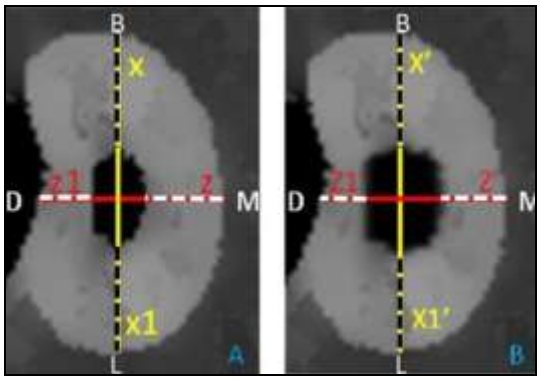

Fig 1: Pre and post instrumentation image measurement parameters.

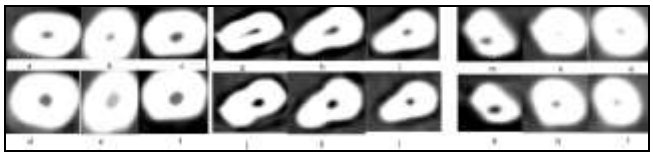

Fig 2: Pre-Instrumentation images of hand K files (a-c), Waveone gold files (g-i), Protaper Next files (m-o) at 3mm, 6mm and 9mm respectively. Post Instrumentation images of Hand K files (d-f), Waveone gold files (j-l), Protaper next files (p-r) at 3mm, 6mm and 9mm respectively

Table 1: Mean Centering ability of Hand K files, Protaper next and Wave One gold systems at 3mm, 6mm and 9mm at mesial and distal directions.

	3 mm Mean (SE)	6 mm Mean (SE)	9 mm Mean (SE)
Hand K Files	0.33 (0.11)	0.35 (0.10)	0.37 (0.16)
Protaper Next	0.57 (0.11)	0.44 (0.11)	0.51 (0.09)
Waveone Gold	0.47 (0.10)	0.45 (0.09)	0.4 (0.11)

Table 2: Mean Centering ability of Hand K files, protaper next and Wave One gold systems at 3mm, 6 mm, and 9 mm at buccolingual directions.

	3 mm Mean (SE)	6 mm Mean (SE)	9 mm Mean (SE)
Hand K Files	1.005(0.44)	2.07(0.94)	1.67(0.53)
Protaper Next	2.42(1.03)	1.38(0.34)	0.82(0.23)
Waveone Gold	1.80(0.90)	0.98(0.27)	1.16(0.37)

6. Conclusions

Within the limitations of this study, it could be concluded that Reciprocating Waveone gold files might produce a better centering ability compared with Conventional Hand K files and Protaper Next file system though the results are statistically insignificant. The above method might produce procedural errors in measurements due to its lesser resolution of images, which might be the reason for statistically insignificant results. Consequently, the use of better three-dimensional imaging systems for future analysis such as Micro Computed Tomography and ex - vivo studies could add important information and accuracy in this content.

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