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Original Research Article

Comparative evaluation of nickel titanium rotary instruments on canal transportation and centering ability in curved canals by using cone beam computed tomography: An in vitro study

Krishnaveni Krishnaveni[1,*], Nikitha Kalla[2], Nagalakshmi Reddy[3], Sharvanan Udayar[4]

[1]*Dept. of Conservative Dentistry and Endodontics, KVG Dental College and Hospital, Sullia, Karnataka, India*
[2]*Dept. of Conservative Dentistry and Endodontics, Narayana Dental College and Hospital, Nellore, Andhra Pradesh, India*
[3]*Dept. of Conservative Dentistry and Endodontics, G Pulla Reddy Dental College and Hospital, Kurnool, Andhra Pradesh, India*
[4]*Dept. of Community Meicine, Kodagu Institute of Medical Sciences, Madikeri, Karnataka, India*

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A B S T R A C T

Objective: The aim of this study was to compare canal transportation and centering ability of different nickle titanium systems using Cone beam computed tomography in curved canals.
Materials and Methods: Ninety mandibular molars with angle of curvature ranging from 10°– 40° were randomly allocated into six experimental groups containing 15 teeth in each group. Preinstrumentation scans were taken with CBCT with constant exposure parameters before and after instrumentation. Six grouped specimens were instrumented with Wave One, Twisted File, Hyflex CM, K3XF, ProTaper Next, NeoNiTi file respectively. Post instrumentation the specimens were scanned by CBCT to obtain postoperative images. The amount of root canal transportation and centering ability of the instrument were determined. Statistical analysis on collected data was performed using One way analysis of ANOVA, and post-hoc Tukey test (p<0.0.5).
Results: K3XF group showed significantly higher transportation values in the apical third (2mm) than TF group (p=0.01) and Hyflex CM group (p=0.03). The coronal transportation values are higher than the apical values but with no significant difference between them (p>0.05). There was no significant difference in centering ratio values between the six groups (p>0.05) at any of the level.
Conclusion: All the file systems can be safely used, showing satisfactory preservation to the original canal shape with preference of TF files.

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1. Introduction

Achieving the goal of adequate cleaning, shaping of the root canal system and widening remains a challenge during instrumentation of curved canals. The use of inflexible instruments might result in excess removal of dentin from the outer walls of canal in the area apical to curvature and inner walls of canal in the area coronal to curvature instead to symmetrical removal[1] which adopts an hour-glass shape, and may leads to inadequate debridement and complications such as ledge formation, root perforation and excessive thinning of canal walls.[2]

To overcome these complications nickel titanium (NiTi) alloy files which appear highly flexible and elastic have prominently altered the canal procedures and there were numerous modifications in these NiTi files for

* *Corresponding author*.
E-mail address: krishnavenimds@gmail.com (K. Krishnaveni).

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instrumentation of curved canals.[3]

Files like R-phase Twisted file (TF),[4–7] K3XF with the basic features of K3 (SybronEndo)[8] and Hyflex CM rotary instruments (Coltene Whaledent, Allstetten, Switzerland)[9] provides a superior flexibility and increased efficiency and safety thereby reducing the risk of ledging, transportation or perforations.[10] Wave One (WO) (Dentsply Maillefer, Ballaigues, Switzerland)[11–13] and other rotary file systems like ProTaper Next (PTN) (Dentsply Maillefer, Ballaigues, Switzerland) and NeoNiTi (Neolix, France) have shown similar mechanisms.[14] All these files have shown better centering ability and has less chances of transportation.

The present in-vitro study was conducted with the objective of comparing canal transportation and centering ability of six different NiTi systems like WO, TF, Hyflex CM, K3XF, PTN, NeoNiTi file systems using Cone beam computed tomography (CBCT).

2. Materials and Methods

This in vitro study was conducted on 180 extracted human mandibular first molars with curved mesial roots. Teeth with completely formed apices, Mesial root canal of mandibular molars with angle of curvature 10^o- 40^o according to method described by Estrla et al[15] were included in the study. Teeth with root caries, cracks, resorption, calcification incomplete apices and ≤10 mm root length were excluded from the study

Primary radiographs of teeth were taken in mesiodistal and buccolingual directions for selection of the samples and roots were examined under Stereomicroscope at x12 magnification for absence of cracks or fracture lines. Ninety teeth with a distinct mesiobuccal (MB) canal and with independent foramen were randomly selected selected from the total teeth. Endodontic access cavities preparation was done using round bur (Dentsply Maillefer) and MB canal orifice was explored with a ISO size 10 K-file (Mani Inc.,Togichi, Japan) which was passively advanced into the canal until it is visible at the apical foramen. Working length (WL) was established by subtracting 1mm from this length. Later each tooth was sectioned through the furcation and the mesial portion of the root and crown was used in the study. These ninety teeth were randomly divided into six experimental groups containing 15 teeth in each group. Pre instrumented root canals scan by using CBCT imaging (Carestream, India) with 10×5 field of view (FOV) were analyzed with CS 9300 software for the 3D multiplanar reconstruction and measurements (Figure 1). After initial scans, in all the groups glide path was performed with a size 15 K-file with RC-Prep as lubricant.

2.1. Canal preparation

Group 1 was instrumented with WO, group 2 with TF and group 3 was instrumented with Hyflex CM. Likewise Groups 4, 5 and group 6 were instrumented with K3XF, PTN and NeoNiTi respectively.

Post instrumentation scans were obtained with similar parameters and position as pre instrumentation scans by CBCT imaging. Canal transportation of the root canals were then analysed at three cross-sectional planes of pre and post instrumentation images at 2, 5, 8 mm from the apical end of the root. The CBCT images of the samples were analyzed with CS 3D Imaging software with axial slice thickness 180um.[16,17]

2.2. Canal transportation and centering ability

Transportation at each level was calculated using the following formula: $(a_1 - a_2)$ - $(b_1 - b_2)$ wherein a_1 and a_2 represented the shortest mesial distances and b_1 and b_2 represented the shortest distal distances from the outside of the curved root to the periphery of the uninstrumented and instrumented canals respectively(Figure 1). A result of zero indicates no canal transportation, positive result indicates transportation towards the mesial aspect of the root and negative result indicates transportation towards the distal aspect of the root.[18]

Canal centering ratio at each level was calculated using the formula $(a_1 - a_2)$ / $(b_1 - b_2)$.If these numbers were unequal, the numerator for this formula would be the smaller of the two numbers. A result of one indicates perfect centring ability. The closer the result is to zero, the worse is the ability of the instrument to remain centered.Pre and post operative cross sectional CBCT images of the six groups at three levels were shown in (Figures 2a&2b).

2.3. Statistical analysis

The collected data was analyzed by SPSS 20.0 software for Windows (SPSS Inc., Chicago, IL, USA). Canal transportation was analyzed with one way ANOVA and Tukeys post-hoc test was used to determine statistically significant differences between the six groups at three different levels and p value less than 0.05 was considered as statistically significant.

3. Results

Table 1 shows the mean transportation and centering ability scores at coronal, middle and apical levels in all the comparative groups. With regard to canal transportation scores lower mean values in the apical and middle levels were observed in TF group compared to other groups whereas K3XF group showed the higher mean values in all the levels compared to other groups. ANOVA test showed that there was significant difference between the six groups (p<0.05) at the apical level in contrast to coronal and middle levels. Groups TF and K3XF showed higher and lower mean apical centering ratio value respectively and there was no significant difference between the six groups at coronal, middle and apical levels (p>0.05).

Pair wise comparisons by Tukey multiple post-hoc test in the apical region, there was significant difference observed between the canal transportation scores of TF group and K3XF group (p=0.01) and between Hyflex CM and K3XF group (p=0.03) and there was no significant difference between the six groups was observed with regard to centering ability.

Figure 2 a,b shows root canal transportation in apical, middle and coronal third in six groups. Although the K3XF caused greater canal transportation in the apical third and Twisted files and Hyflex CM showed less canal transportation when compared to all other group these differences were not statistically significant. Similar findings were observed with respect to canal centering ability (Table 1).

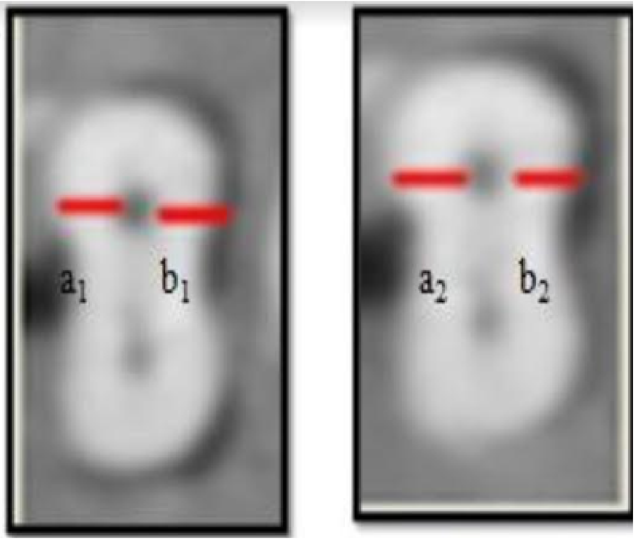

Fig. 1: Pre and post instrumentation cross-sectional image for measurement in CBCT

4. Discussion

Root canal shaping is a critical aspect of endodontic treatment as it influences the outcome of subsequent phases like canal irrigation, filling and overall success of treatment. This shaping should produce a continuously tapered preparation keeping the foramen as small as possible and maintaining the original canal shape.[19–21]

To minimise these procedural errors the instruments with different metallurgy used for instrumentation of curved canals should be flexible to follow the root canal.[22–24] The present in vitro study compared these six file systems with different manufacturing methods to evaluate

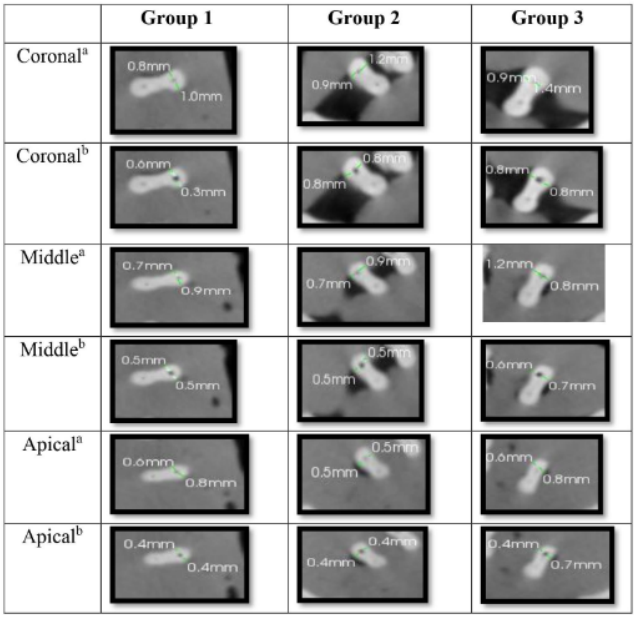

Fig. 2: Pre and post instrumentation image of group 1 to 3 three different levels coronal (8mm), middle (5mm) and apical (2mm); **a:** Pre-instrumentation; **b:** Post instrumentation

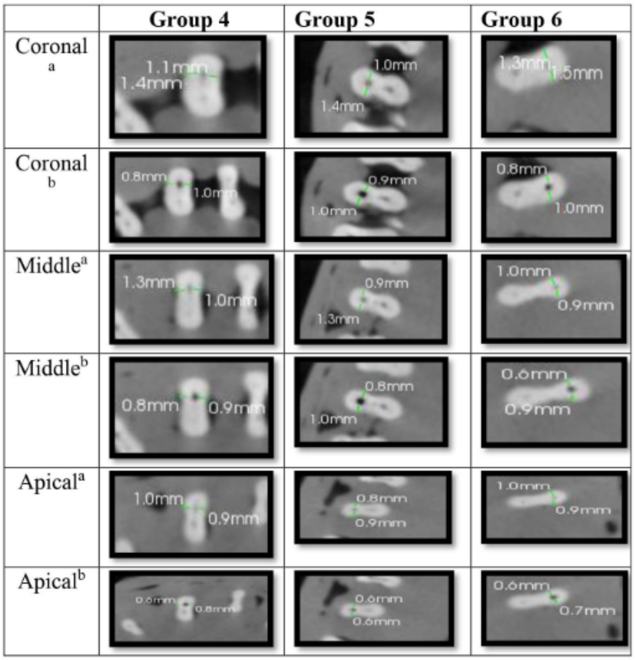

Fig. 3: Pre and post instrumentation images of group 4 to 6 at three different levels coronal (8mm), middle (5mm) and apical (2mm);). **a:** Pre-instrumentation; **b:** Post instrumentation

Table 1: Comparison of six groups with respect to transportation andcentering ratio scores in coronal, middle and apical levels.

Instrument Groups	Coronal (Mean±SD)	Middle (Mean±SD)	Apical (Mean±SD)
Canal transportation score			
Wave One	0.27±0.26	0.20±0.14	0.14±0.12
Twisted file	0.16±0.17	0.10±0.11	0.06±0.07
Hyflex CM	0.16±0.24	0.11±0.20	0.07±0.08
K3XF	0.31±0.29	0.22±0.14	0.19±0.13
ProTaper Next	0.22±0.31	0.16±0.28	0.11±0.12
NeoNiTi	0.21±0.27	0.19±0.19	0.12±0.11
F-value	0.78	0.98	3.03
P-value	0.56	0.43	0.01*
Cana centering ratio score			
Wave One	0.51±0.30	0.56±0.29	0.64±0.29
Twisted file	0.56±0.34	0.67±0.31	0.74±0.30
Hyflex CM	0.56±0.35	0.70±0.35	0.71±0.29
K3XF	0.51±0.37	0.56±0.30	0.51±0.31
ProTaper Next	0.50±0.34	0.51±0.33	0.66±0.34
NeoNiTi	0.60±0.30	0.53±0.30	0.68±0.28
F-value	0.20	0.87	1.02
P-value	0.95	0.50	0.40

*p<0.05

Table 2: Comparison of three levels with transportation scores in six groups by One way ANOVA

Groups (Mean±SD)	Coronal	Middle	Apical	F-value	p-value
Canal transportation score					
Wave One	0.27±0.26	0.20±0.14	0.14±0.12	1.74	0.18
Twisted file	0.16±0.17	0.10±0.11	0.06±0.07	2.64	0.08
Hyflex CM	0.16±0.24	0.11±0.20	0.07±0.08	0.86	0.42
K3XF	0.31±0.29	0.22±0.14	0.19±0.13	1.58	0.21
ProTaper Next	0.22±0.31	0.16±0.28	0.11±0.12	0.66	0.52
NeoNiTi	0.21±0.27	0.19±0.19	0.12±0.11	0.75	0.47
Cana centering ratio score					
Wave One	0.51±0.30	0.56±0.29	0.64±0.29	0.75	0.47
Twisted file	0.56±0.34	0.67±0.31	0.74±0.30	1.22	0.30
Hyflex CM	0.56±0.35	0.70±0.35	0.71±0.29	0.92	0.40
K3XF	0.51±0.37	0.56±0.30	0.51±0.31	0.12	0.87
ProTaper Next	0.50±0.34	0.51±0.33	0.66±0.34	1.11	0.33
NeoNiTi	0.60±0.30	0.53±0.30	0.68±0.28	0.93	0.40

canal transportation and centering ability by using CBCT imaging.

On comparing the results obtained in the present study, the two single-file systems WO Group and NeoNiTi group showed no significant difference in transportation and centering ratio values (p>0.05) compared to multiple-file systems like TF, Hyflex CM, K3XF and PTN in all the three levels. This is in accordance with previous studies comparing the shaping ability of single-file systems and conventional ones using a full range of instruments and have shown results similar to the present study, that all the systems result in satisfactory preservation of the original canal shape.[23,25,26]

Comparing the results between these two single-file systems in the present study, NeoNiTi has lower mean apical transportation and better mean centering ability values compared to WO transportation value but with no significant difference between them (p>0.05). Superior results of Neo NiTi might be due to its metallurgical properties like, EDM process and its design features like it has non-homothetic rectangular CS with rounded Gothic tips. This was in accordance with Moazzami F et al. study in which two single-file systems, NeoNiTi and Reciproc (R) used in continuous motion and reciprocating motion respectively are compared in transportation using CBCT.[27]

On the contrary, some studies stated that reciprocating movement caused no significant decreased transportation and centering ability.[28,29] The results of the present study shown that WO group (reciprocating single file system) showed no significant difference in transportation and centering ability compared to rotating single and multiple file systems (NeoNiTi, TF, Hyflex CM, K3XF, PTN) (p>0.05). The results were consistent with a previous study done by Park HJ who reported that no significant difference in transportation between WO and other groups.[30]

Significantly higher transportation values were shown by K3XF group in the apical region. This significant difference was observed between K3XF group and the groups of TF and Hyflex CM files. Similarly lower apical centering ratio values were also reported by K3XF (0.51) but with no significant difference between the other groups. Though K3XF is made of heat treated R-phase to enhance flexibility and resistance to cyclic fatigue, however this heat treatment showed no impacted on the performance of this instrument in curved canals[31] and showed significantly high transportation compared to TF which is also manufactured of the same R-phase and Hyflex CM manufactured of CM-wire. As K3XF has CS configuration similar to K3, this may be a factor contributing to higher transportation and centering ability values as it lowers the bending properties.

The present study also shown that K3XF caused significantly higher apical transportation values than TF and Hyflex CM is in agreement with above mentioned studies where K3XF doesn't show superior results compared to different file systems.[31,32] Zhao et al. evaluated the shaping properties of Hyflex CM, TF, K3 system using μ-CT and reported that TF has less apical transportation than K3 and there is no significant difference among Hyflex and TF in shaping curved root canals.[33] So this R-phase heat treatment showed no impacted on the performance of this instrument in curved canals.[34]

TF and Hyflex CM groups produced less mean apical transportation and high centering ratio values than other file systems. Altunbas D found that TF instruments showed a greater tendency to preserve the curvature of curved canals of the mandibular molar than K3 instruments by using two-dimensional photographic technique.[34] The superiority of TF compared to other groups might be due its manufacturing by 3 processes (R-phase, twisting, surface treatment).[35,36]

TF and Hyflex CM showed superior results due to their thermal pre-treatment of the alloy during manufacturing which makes them more ductile, reducing the magnitude of the restoring forces[37] and their CS designs might also has contributed to superior results of these two file systems.

Our study reported that PTN group showed no significant difference in transportation and centering ability values at all the three levels compared to other groups (p>0.05). This M-wire and swaggering motion might have contributed to the present results which is in consistent with study done by Saber et al who compared the in vitro shaping ability of PTN, iRaCe and Hyflex CM rotary NiTi files on apical transportation and centering ability.[38]

Of the six groups WO goup showed more difference between the coronal and apical level transportation values than the single-file NeoNiTi and multiple-file Hyflex CM. This might be due to lesser taper in NeoNiTi (0.06) compared to WO (0.08) and non-homothetic rectangular CS with rounded Gothic tips.

The results of centering ability of six groups have shown that all the file systems tested remained centered with no significant difference between them (p>0.05). It can be contributed to the noncutting tip design of the tested instruments which act as a guide to allow easy penetration with minimum apical pressure.[38]

5. Conclusion

The results of the present study demonstrated that under the experimental conditions, all the tested file systems showed some degree of apical transportation, but it is well within the acceptable limit (0.3). Of the file systems compared TF resulted in superior shaping ability in curved canals and K3XF showed higher transportation values but the clinical relevance is of limited importance. So, all the six file systems maintained the original canal anatomy with similar transportation and better centering ability.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Author biography

Krishnaveni Krishnaveni, Senior Lecturer

Nikitha Kalla, Student (MDS) https://orcid.org/0000-0001-6699-1941

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