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Evaluation of Centring Ability of three Nickel Titanium Rotary Files for Root Canal Preparation: An Invitro Cone Beam Computed Tomography Assessment

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ABSTRACT**Introduction**

Root canal therapy has been a primary modality to treat the teeth with infected root canals. The treatment is carried out with the primary aim to remove the infected tissue and at the same time maintain the root canal anatomy ¹. Endodontic treatment used to be a tedious procedure in the past requiring multiple visits for completion of procedure ². The latest developments in the equipment used for endodontics such as magnifying devices, electronic apex locators, engine driven rotary nickel titanium files etc. have not only enhanced the success rates of these procedures but have also substantially decreased the time and visits needed for treatment completion. These contemporary devices can help the clinician complete the endodontic treatment in a single visit. Practice of nickel titanium (NiTi) rotary file is becoming ubiquitous because it has shape memory and better flexibility compared to stainless steel files. Niti instruments are anticipated to perform better by remaining centred in the canal during root canal instrumentation because of their increased flexibility. These are employed for mechanical preparation of root canals during endodontic treatment or removal of gutta percha points if needed. It has been in use since 1991, and endo motors are used to prepare the canals. These properties make them better than conventional stainless-steel files. These files maintain the canal morphology thus minimizing the procedural errors like canal transportation, apical debris extrusion, perforation and change in canal centrality etc. ^{2,24,25}.

A comprehensive knowledge regarding the root canal morphology is important to perform adequate treatment. The dental pulp is the living and soft tissue part of the tooth enclosed in its root canals and pulp chamber. It resides in the internal spaces of the tooth. The outer border of pulp cavity imitates the shape of the tooth. Recent literature reveals that root canal system is not a solitary canal extending unvaryingly from the orifice to the apex, rather it is intricate because of division and fusion of canals as they progress to the root apex. The root canal begins from the orifice located in the pulp chamber and runs through the roots to open into the periodontium via the apical foramen ³. These varied configurations can be classified so that their shape is easy to identify, communicate and for adequate treatment planning based on the shape of the canal. An ideal classification system for the root canals should define the number of roots, the canals present within these roots and their configuration running from the orifice to the apex ⁴.

As the endodontic treatment showed advances and new sources of technical applications in clinical practice, it became easier to identify the diagnosis and quality of treatment given. One of these very important advances is the computed tomography which helps in the planning, therapy, diagnosis and prognosis of various diseases. The use of CBCT is becoming widespread in dentistry and is applicable both in research and clinical dentistry's provides a more accurate diagnosis of the endodontic problems which is immensely important for the successful treatment. CBCT can expose additional canals, fractures, extent of canal and any other abnormalities that the 2D radiograph fails to show. The map reading approach can allow the clinicians to easily reduce image evaluation problems as compared to the conventional radiograph diagnosis ⁵.

Since it has obvious advantages over the conventional 2D radiographs interpretation of which can cause errors ^{5,23}. CBCT is a non-destructive technology and renders approvingly accurate, great resolution, cross-sectional and 3D images that are fully computable and consistent. Therefore, Cone beam computed tomography (CBCT) has been advocated for pre- and post-instrumentation evaluation of centring ability of rotary files in root canals ^{6,7,8}.

This study was carried out to compare the centring ability of three NiTi rotary file systems. The null hypothesis tested was that there would be no inconsistency among the three-single file NiTi rotary systems considering the investigated parameters.

The rotary files picked to carry out the study were HyFlex EDM, Xp Endo Shaper and Wave-one Gold. The canals were prepared according to the manufacturers specifications and then CBCT images were taken at 3mm,6mm and 9mm from the apex to measure the centring ability of the file systems.

Key words: Endodontics, NiTi Rotary file systems, Centring Ability

MATERIALS AND METHOD

60 Freshly extracted mandibular first premolars, with fully formed apices and with single canals were utilized for the study. Teeth that had calcifications, additional canals or resorptions were excluded from the study. Teeth were divided into three groups with 20 teeth each.

Each tooth was decoronated to a standardized root length of 14mm. Access opening was made using a round bur and the canal patency was established. The working length was established

by inserting a size 10 K-file till the root canal terminus and subtracting 1 mm from this measurement. Glide path was prepared up to size 15 K-file. The selected teeth were embedded in acrylic and then mounted horizontally in a customized silicon jig to facilitate their precise positioning on the chin rest of CBCT machine with occlusal plane parallel to the plate. This was done to ensure standardization. Pre-instrumentation CBCT scans of the roots were performed. The CBCT with FOV technology called at the Planmeca Promax was used, along with Planmeca Romexis® scanner software. Root canal instrumentation was done by three experienced operators employing one rotary file system each, using a standardized endodontic technique following manufacturer's instructions for each group of rotary files.

Group A Hyflex EDM: Glide path 10/0.05 followed by shaping file 25 and then finishing by 40/0.04 at 500 rpm, 2.5 Ncm.

Group B XP Endoshaper: 0.01 initial taper followed by final taper of 0.04 at 800 rpm, 1 Ncm

Group C Wave-one Gold: primary file used with 7% taper and 25 size at 350 rpm.

Copious irrigation was carried out throughout the procedure to wash out the debris with 3ml of 5% sodium hypochlorite (NaOCl) solution using 30-gauge side-vented needles after each file, followed by a final flush 3 ml of saline.

After instrumentation, all the root canals were scanned using CBCT using the same protocol and setting and in the same manner as initial pre-instrumentation scans.

Calculating centering ability

The centering ability was calculated at 3 mm, 6 mm and 9 mm from the apex by using the following criteria

CT was determined by the comparative valuation of undeviating dimensions in the axial sections at above-mentioned levels in pre- and post-instrumentation scans using the following equation:

$CT = (a1 - a2) - (b1 - b2)$, as shown in figure 1.

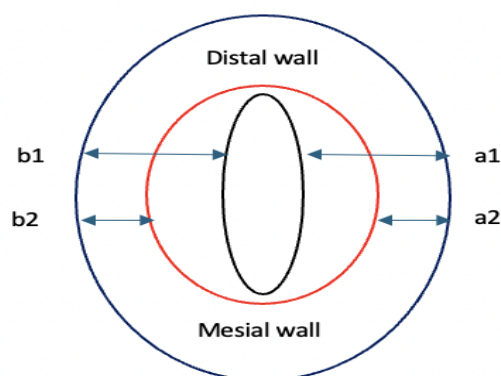
a1 and a2 - shortest distance from the mesial edge of the root to mesial edge of un-instrumented and instrumented canal, respectively,

b1 and b2 - distance from the distal edge of the root to the distal edge of un-instrumented and instrumented canal, respectively.

$CA = (a1 - a2) / (b1 - b2)^{10,21}$

If differences were unequal, smaller value was considered as numerator. Therefore, values equal to 1 indicate perfect CA of instrument and values closer to 0 indicate instrument's lower ability to maintain the central axis of the canal.

Figure 1: Cross-sectional image illustrating canal area measurements.



Statistical analysis

Data was analyzed by using software SPSS 27. Kolmogorov-Smirnov Test was used to check the normality of data and Levene's homogeneity test were applied to check for variance. The P-value was not significant which means the data does not follow the normal distribution. Descriptive statistics of quantitative variables were calculated. For analytical statistics one-way ANOVA and post hoc Tukey test was used for comparison of pre and post intervention and comparison between the groups. P value ≤ 0.05 was considered significant.

RESULTS

Descriptive statistics were carried out for each file system and comparison was carried out at the three root levels 3mm, 6mm and 9mm and intragroup as well.

At 3 mm, Group I and Group II and Group III showed similar values. At 6 mm and 9mm, similar values were observed between the systems with very miniscule difference in the readings were observed.

No statistically significant differences were observed among the groups p value > 0.05 . Table 2

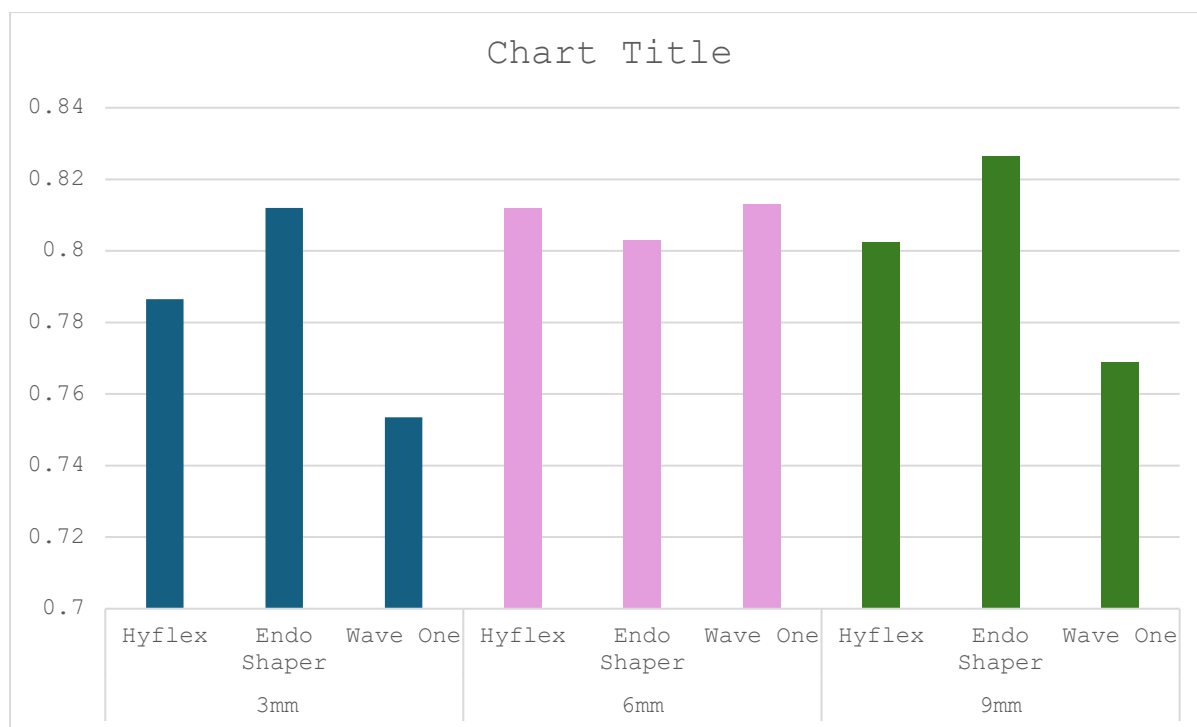
From the observations it can be inferred that the three rotary file systems that were used to prepare the canals are equally effective in preparing the canals and maintaining the canal morphology and centrality. Of all the three systems, Group II, XP Endoshaper gave the best results with the centering ratio closer to one and a P- value of 0. 380.

Table 1: Mean and standard deviation of canal transportation in mm) and cantering ratio values (mm) for the tested groups.

File System	Distance from Apex	Mean	SD	P – Value Post-Hoc	p- value
Group 1 Hyflex	3mm	0.79	0.14	0.786	0.817
	6mm	0.81	0.14	0.802	
	9mm	0.80	0.10	0.812	
	3mm	0.80	0.17	0.803	0.380

Goup II Endoshaper	6mm	0.83	0.21	0.812	0.916
	9mm	0.84	0.17	0.826	
Group III Wave One	3mm	0.75	0.14	0.753	
	6mm	0.81	0.06	0.769	
	9mm	0.79	0.10	0.813	

Table 2: Showing canal centering ability among various groups.



DISCUSSION

Cleaning and shaping is one of the most critical steps of endodontic treatment. The objective is to eliminate the microorganisms and create a funnel shaped canal but at the same time maintain the original canal anatomy to avoid procedural errors ⁹.

The current study focused on premolars with single straight canals to rule anatomical variations like complex canal configurations, degree of curvature confounding the results. CBCT was used in the present study to evaluate the centering ability. It has the advantage of faster acquisition and reform, high resolution with 3D imaging¹⁹. All the sample teeth were prepared to size 25 till the working length. This was done to fulfill the criteria that for comparison of preparation techniques all the canals must be prepared to the same apical diameter. The results of the current study show that all the three file systems had the same centering ability with no significant difference.

The wave one gold is a single reciprocating file system that has a parallelogram shaped cross section ¹⁰. The metal wire is repeatedly heated and cooled before manufacturing which imparts golden color to the file and strength and flexibility. The wave one gold is reportedly 80% more flexible compared to wave one file ^{11,12}. XP endo file is also single file system made with Max

wire technology which gives it the property of super-elasticity. At body temperature it transforms from martensite into austinite form. It can adapt to canal due to expansion and contraction capacity. 4 The current study reveals that wave one gold and XP endo had same centering ability. At 3mm the XP endo had better centering ability compared to wave one gold, but the difference was not statistically significant. This contrasts with some previous studies where XP endo showed better performance compared to wave one gold. This may be due to difference in the methodology, the teeth tested were mostly mandibular molars with curved mesial canals^{13,14,15}. In the current study premolar with straight canals were used. Curved canals are more challenging and more demanding in terms of flexibility of instruments since there is a risk of non-centered preparations in curved canals¹¹.

The Hyflex EDM is the made from a controlled memory wire and with a technology called electric discharge machining. The results of the current study reveal that there was no significant difference between Hyflex EDM and wave one gold in terms of centering ability. Similar results have been reported by previous studies. This can attributed to the manufacturing of Hyflex EDM and its cross section which is different at apical, middle and coronal third making it flexible^{15,18}.

Hyflex EDM and XP endo had the same centering ability according to the current study. Similar findings have been reported by previous studies. Both the files are highly flexible, XP endo with adaptive core technology expands beyond its core size hence maintaining the original canal anatomy. Similarly Hyflex EDM, a controlled memory file, is highly flexible resulting in more centered preparations^{16,23,24}.

In contrast to the current study, some studies that compared the three file systems, reported that XP endo is better compared to Hyflex EDM and wave one gold²⁵. The difference in the results is due to the difference in the methodology. These studies have used mesial canals of mandibular molars^{17,20,22}, while in the current study premolar with single straight canals were used.

A fundamental limitation of the study is the in vitro design of the study that does not truly replicate in vivo conditions. Furthermore, single straight canals are relatively easy to prepare with little risk of procedural errors. Further research is warranted to prove their safety and efficacy in curved canals

CONCLUSION

The results of the current study reveal that XP endo, Wave one gold and Hyflex EDM have the same centering ability resulting centered canal preparations in premolar teeth with single canal.

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