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Research Article

Geometric Analysis of Curved Canals Prepared by HyFlex EDM Versus HyFlex CM Rotary Nickel Titanium Files: An *In-Vitro* Study

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Abstract

Objective: The aim of this study was to compare and evaluate 2 file systems: HyFlex EDM and HyFlex CM in preparing severely curved mesiobuccal canals of human mandibular molars regarding: the centering ability, transportation of the canal and ability to maintain canal radius of curvature, utilizing cone beam computed tomography (CBCT).

Materials and Methods: A sum of thirty mesiobuccal root canals of extracted human mandibular molars having angle of curvature ranging from 25 - 45˚ (according to Schneider) were selected and assigned into two groups; HyFlex EDM and HyFlex CM. The distal roots with the respective part of the crowns of all samples were sectioned and discarded after access cavities preparation and working length determination. Samples were mounted in two molds of acrylic resin for pre and post-instrumentation imaging utilizing CBCT. Root canal preparation was done by each NiTi system according to the manufacturers' instructions. The CBCT images at the root canal levels (3, 5 and 8 mm from the tooth apex) were superimposed using a fusion module of OnDemand 3D App software for dentin thickness measurement. Ability to maintain canal radius of curvature was recorded following Estrela., *et al*. while canal transportation and centering ability were recorded following a formula introduced by Gambill., *et al*. Data was tabulated and statistically analyzed.

Statistical Analysis: Data was tabulated and statistically analyzed; Independent samples t-test was used for comparing the change in the radius of canal curvature angle between the two groups and also was used for comparing the variables between the two groups at each root canal level. The significance level is considered at P ≤ 0.05.

Results: The HyFlex EDM recorded statistically lower mean value at the 5 mm level, while at the 8 mm level it recorded statistically higher mean value of root canal transportation than HyFlex CM. There was no statistically significant difference regarding direction of root canal transportation and centering ability between the two rotary systems. Concerning the ability to maintain canal radius of curvature, a statistically significant difference was found between pre and post radii of curvature for each file system, but no significant difference was found between the two systems.

Conclusion: Under the limitations of this *in vitro* study, it can be concluded that; HyFlex EDM and HyFlex CM systems were relatively safe in preparation of curved root canals and were not able to achieve perfect centering ability during root canal preparation. HyFlex CM has shown more straightening regarding the radius of curvature.

Keywords: Canal Transportation; Centering Ability; Canal Radius of Curvature; HyFlex EDM; HyFlex CM; CBCT

Introduction

Successful root canal treatment mainly depends on the removal of microorganisms, infected dentine and organic tissue by chemomechanical preparation of the root canal system. Therefore, the cleaning and shaping ability of any root canal instrument is important for success of the root canal treatment [1].

According to Schilder, the anatomy of the root canal after instrumentation should show a continuous taper shape from the apical foramen to the orifice while preserving the apical foramen and without any deviations from the original canal curvature, with the largest diameter at the orifice and the smallest diameter at the apical foramen [2,3]. However, the use of the traditional stainless steel instruments caused transportation of the apical foramen to a new iatrogenic position which leads to treatment failure, creation of ledges, elbows, perforation and instrument fracture preventing adequate preparation of the root canal system and inability of proper condensation of root filling materials into the root canal [3]. Inability to properly clean and shape the root canal system leads to failure of our endodontic therapy [4].

In 1988, Walia., *et al*. was the first to introduce Nickel-Titanium (Ni-Ti) rotary endodontic instruments [5], which revolutionized the endodontic treatment. These Ni-Ti instruments resulted in reducing operator fatigue and treatment time and minimizing mishaps that took place with the stainless steel instruments [5,6]. In addition, Ni-Ti files preserve the original canal anatomy and reduce the probability of canal transportation during preparation [7].

To improve the properties of Ni-Ti files manufactures have developed several methods to improve the instrument strength, flexibility, cutting efficiency, cyclic fatigue resistance and reduce the risk of fracture [8]. Manufacturers have developed new manufacturing technique by a series of thermo-mechanical processes which produce a stable martensite phase. Ni-Ti files with thermal processing (e.g. CM Wire) contain a mixture of austenite and martensite structures at body temperature. The martensitic phase of Ni-Ti has some unique properties that have made it ideal for root canal instrumentation [9].

Electrical discharge machining (EDM) is an innovative machining process that eliminates the chance of mechanical stress as in the traditional grinding process. EDM instruments demonstrates a superior hardening to the NiTi surface, resulting in a significant greater resistance to cyclic fatigue and superior cutting efficiency [10].

Recently introduced HyFlex EDM (Coltene/Whaledent) instruments are manufactured from the same type of controlled memory wire but are produced via electro-discharge machining (EDM). The file is characterized by a high fatigue resistance, greater flexibility and the possibility to be easily bended during use, which leads to a reduced risk of ledging, transportation and perforation making it ideal to prepare curved root canals [10,11]. Several studies utilizing HyFlex EDM has demonstrated better shaping ability when compared with Reciproc and ProTaper Next [12,13].

HyFlex CM (Coltene/Whaledent, Switzerland) was introduced by Coltene utilizing the CM technology. Previous studies using this system have shown that it produces less straightening of the canal, less apical transportation and maintains the original shape of root when compared to Revo-S, ProTaper Next and iRaCe [14-16].

Cone Beam Computed Tomography (CBCT) is a three dimensional imaging system. Cone beam computed tomography (CBCT) overcomes most of the limitations accompanied by conventional radiography like two dimensional imaging, anatomic superimposition and image distortion. CBCT produces clear images with higher resolution, therefore useful tool in assessment of canal shaping and canal anatomy [17].

When this study was undertaken, a comprehensive literature research indicated that there was no available study evaluating the shaping ability of HyFlex EDM in comparison with HyFlex CM in shaping natural curved root canals.

Aim of the Study

The aim of this study was to analyze the geometric changes in curved canals prepared by HyFlex EDM versus HyFlex CM rotary Nickel Titanium.

Materials and Methods

Experimental teeth

A total of 30 extracted mandibular molars that were extracted for various reasons with an average length of (20 - 22 mm) were collected from the outpatient clinic, Oral and Maxillofacial Department, Faculty of Dentistry, Cairo University, Cairo, Egypt. Teeth were cleaned by using ultra sonic scaler to remove any calculus and hard deposits and immersed in 5.25% sodium hypochlorite to remove any soft tissues. Teeth were stored in saline till usage.

Periapical radiographs were taken during sample selection for each tooth to make sure that all the teeth had type I mesiobuccal canals tooth was carried out and to ensure that the curvature of the mesiobuccal canal was within the range of (25^o - 45^o) according to Schneider's method [18]. Teeth having immature canals, calcification, endodontically treated canals or those exhibiting internal or external resorption were excluded.

Sample preparation

Access cavity was prepared by the aid of a high-speed round carbide bur and an Endo-Z bur with coolant. K-file 10 was placed into the mesiobuccal canal (MB) to confirm patency. Irrigation before instrumentation of the canals was done by 2.5% sodium hypochlorite solution. The distal portion of each tooth was resected at the furcation level using stainless steel disk and discarded. The remaining crown was reduced and flattened until the mesial root reached the length of 16 mm. K-file 15 was used to establish glide path. The thirty roots were assigned randomly into two groups (n = 15) according to the rotary system utilized for root canal instrumentation; HyFlex CM group and HyFlex EDM group. Samples were mounted inside plastic square blocks filled with acrylic resin.

Pre-instrumentation imaging

Before canal instrumentation, each mold was scanned using a CBCT machine. Images were acquired using Planmeca ProMax 3D Mid Proface (Planmeca, Finland) with same criteria followed by other authors [19].

Pre-operative CBCT measurements

Radiographic measurements of dentin thickness

The software OnDemand 3D App (Cybermed, South Korea) was employed to superimpose preoperative and postoperative scans using the fusion module. For measuring dentin thickness change after instrumentation, the apex of a root was located. A vertical line was drawn parallel to longitudinal axis of the root where another three horizontal points were located at 3, 5 and 8 mm from the apex for both scans. At the three located horizontal points, axial sections were taken at the mesial and distal walls of the canal lumen for both scans simultaneously.

Radiographic measurements of dentin thickness

Estrela., *et al*. [3] developed a method to evaluate the root curvature radius. Two equal lengths lines were drawn to the root canal. The mid-point will be determined for of each line. Two lines perpendicular to the mid points were drawn until they intersect at a point. This point is called circumcenter. The radius of canal curvature is the distance between the center of each line and the circumcenter [3].

Root canal instrumentation

The samples were prepared according to according to the manufacturer's recommendations for both groups by the investigator. In both groups, E-connect pro endo-motor was used to perform root canal instrumentation. 30-gauge side-vented needle plastic syringe was used to irrigate with 3 ml of 2.6% NaOCl between the file sizes. We continued till each file reached the full working length.

Post instrumentation evaluation

Each sample was rescanned using (CBCT) with same machine parameters mentioned in the pre-instrumentation imaging. OnDemand 3d App software (Cybermed, South Korea) using the fusion module was used to superimpose the postoperative scan over the preoperative one.

The mesio-buccal roots were sliced at 3, 5 and 8 mm from the apex. These images were evaluated for post-instrumentation changes. Each of the slices was parallel to the mounted tooth at the horizontal plane. Each slice was evaluated for.

Canal transportation

Canal transportation is the deviation from the canal original axis (measured in millimeters) after instrumentation.

Canal transportation was evaluated using the method developed by Gambill., *et al.* [20] measuring the distance from the edge of the canal to the periphery of the root (mesial, distal) on pre- and post-instrumentation slice images at pre-determined levels (3, 5 and 8 mm) obtained by CBCT scanner.

The following formula was used for calculating the canal transportation:

Mesiodistally: (M1-M2)-(D1-D2)

Where:

- M1 is the shortest distance from the mesial edge of the root to the mesial edge of the un-instrumented canal.
- M2 is the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal.
- D1 is the shortest distance from the distal edge of the root to the distal edge of the un-instrumented canal.
- D2 is the shortest distance from the distal edge of the root to the distal edge of the instrumented canal.
- The Zero result means No transportation. Positive results indicate mesial transportation, while negative results indicate distal transportation.

Canal centering ratio

The mean centering ratio indicates the ability of the instrument to keep centered inside the canal during instrumentation. Canal centering will be calculated by the method developed by Gambill., *et al* [20].

This was achieved by using the following formula:

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

Where:

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

A result of one indicates perfect centering ability, while if the result was less than one, this indicates less centering ability.

Ability to maintain canal radius of curvature

Estrela., *et al*. [3] developed a method to evaluate the root curvature radius that previous mentioned.

Percentage of change of radius was calculated using the following formula:

$$\frac{canal\ radius\ post\ preparation - canal\ radius\ before\ preparation}{canal\ radius\ before\ preparation} \times 100$$

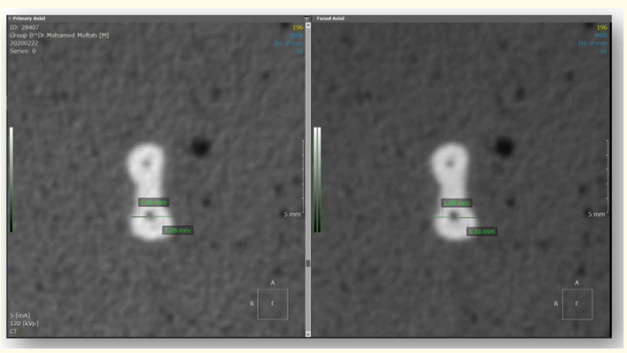

Figure 1: A CBCT image showing measurement of the dentin thicknesses on the axial view of a selected specimen at 3 mm level.

Statistical analysis

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests, ability to maintain canal radius of curvature data showed parametric (normal) distribution while centering and canal transportation data showed non-parametric (not-normal) distribution.

For parametric data, paired sample t-test was used to compare between two groups in related samples. Independent sample t-test was used to compare between two groups in non-related samples.

For non-parametric data, Mann Whitney test was used to compare between two groups in non-related samples. Friedman test was used to compare between more than two groups in related samples. Wilcoxon test was used to compare between two groups in related samples. The significance level was set at p ≤ 0.05.

Results

Regarding mesiodistal canal transportation, both groups showed a degree of transportation at the selected levels (Figure 1 and table 1). A statistically significant difference was found between the HyFlex CM and the HyFlex EDM groups at both the 5 mm level and 8 mm level. The HyFlex EDM group there was found a statistically significant difference between (8 mm) and each of (3 mm) and (5 mm) levels.

Regarding overall mesiodistal canal transportation, there was no statistically significant difference between the HyFlex CM and HyFlex EDM groups (Table 2).

Regarding canal transportation direction frequency, no statistically significant difference was recorded between the two rotary systems (Table 3).

Regarding Overall canal mesio-distal transportation frequency, it was found that the most of transportation of the HyFlex CM group and HyFlex EDM group was to the distal direction. There was

Variables	Mesio-distal Canal transportation						
	3 mm		5 mm		8 mm		p-value
	Mean	SD	Mean	SD	Mean	SD	
CM	0.055^{aA}	0.012	0.063^{bA}	0.016	0.055^{bA}	0.015	0.472ns
EDM	0.049^{aB}	0.018	0.043^{aB}	0.012	0.067^{aA}	0.013	< 0.001*
p-value	0.230ns		0.001*		0.035*		

Table 1: The mean, standard deviation (SD) values of mesio-distal canal transportation of the studied groups.
*: Significant (p < 0.05); ns: Non-Significant (p > 0.05).

Variables	Canal transportation	
	Mean	SD
CM	0.058	0.015
EDM	0.053	0.018
p-value	0.185ns	

Table 2: The mean, standard deviation (SD) values of overall mesio-distal canal transportation in the two groups.
*: Significant (p < 0.05); ns: Non-Significant (p > 0.05).

no statistically significant difference between the HyFlex CM and HyFlex EDM groups (Table 4).

Concerning the centering ability, there was no statistically significant difference between the two rotary instruments at all levels (Table 5 and 6).

Regarding the ability to maintain radius of canal curvature, there was a statistically significant difference between pre and post

Variables		Canal transportation									
	3 mm			5 mm			8 mm			p-value	
	n	%	Subscripts	n	%	Subscripts	n	%	Subscripts		
CM	No transportation	0	0	aA	1	6.7%	aA	0	0%	aA	0.779ns
	Mesial	6	40%		4	26.7%		7	46.7%		
	Distal	9	60%		10	66.7%		8	53.3%		
EDM	No transportation	3	20%	aA	2	13.3%	aA	1	6.7%	aA	0.682ns
	Mesial	4	26.7%		6	40%		9	60%		
	Distal	8	53.3%		7	46.7%		5	33.3%		
p-value		0.439ns			0.270ns			0.218ns			

Table 3: The frequency of mesio-distal canal transportation direction of the two groups at the three levels.
*: Significant (p < 0.05); ns: Non-Significant (p > 0.05).

Variables		Canal transportation		
n		%	Subscripts	
CM	No transportation	1	2.2%	a
	Mesial	17	37.8%	
	Distal	27	60%	
EDM	No transportation	6	13.3%	a
	Mesial	19	42.2%	
	Distal	20	44.4%	
p-value		0.071ns		

Table 4: The frequency of total canal transportation direction for the two groups at all levels.
Significant (p < 0.05); ns: Non-Significant (p > 0.05).

Variables	Centering ability						
	3 mm		5 mm		8 mm		p-value
	Mean	SD	Mean	SD	Mean	SD	
CM	0.467^{aA}	0.090	0.521^{aA}	0.081	0.501^{aA}	0.055	0.344ns
EDM	0.479^{aA}	0.075	0.536^{aA}	0.085	0.507^{aA}	0.087	0.173ns
p-value	0.632ns		0.678ns		0.819ns		

Table 5: The mean, standard deviation (SD) values of centering ability of the two groups.
*: Significant (p < 0.05); ns: Non-Significant (p > 0.05).

Variables	Centering ability	
	Mean	SD
CM	0.497^{a}	0.078
EDM	0.507^{a}	0.084
p-value	0.707ns	

Table 6: The mean, standard deviation (SD) values of overall centering ability in different groups.
*: Significant (p < 0.05); ns: Non-Significant (p > 0.05).

radii of curvature for each file system, but no significant difference was recorded between the two rotary systems (Figure 2, Table 7 and 8).

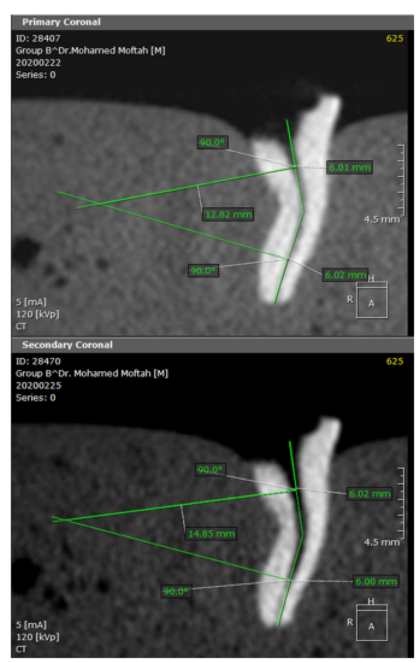

Figure 2: A CBCT image showing measurement of the radii of curvature on the sagittal view of a selected specimen.

Variables	Ability to maintain canal radius of curvature			
	CM		EDM	
	Mean	SD	Mean	SD
Pre	12.18[a]	3.03	15.70[a]	4.06
Post	13.28[b]	3.31	17.01[b]	4.31
p-value	< 0.001*		<0.001*	

Table 7: The mean, standard deviation (SD) values of change in radius of canal curvature in the studied groups.

*: Significant (p < 0.05); ns: Non-Significant (p > 0.05).

Variables	Ability to maintain canal radius of curvature			
	CM		EDM	
	Mean	SD	Mean	SD
Pre	12.18[a]	3.03	15.70[a]	4.06
Post	13.28[b]	3.31	17.01[b]	4.31
p-value	< 0.001*		<0.001*	

Table 7: The mean, standard deviation (SD) values of change in radius of canal curvature in the studied groups.

*: Significant (p < 0.05); ns: Non-Significant (p > 0.05).

Variables	Total change of radius curvature		
	Mean	SD	%
CM	1.10[a]	0.32	8.33%
EDM	1.31[a]	0.31	7.81%
p-value	0.216ns		

Table 8: The mean, standard deviation (SD) values and the percentage of change in radius of canal curvature of the two groups.

*: Significant (p<0.05); ns: Non-Significant (p > 0.05).

Discussions

The main goal of the endodontic treatment is complete removal of the vital, necrotic tissues and infected root dentine from the root canal system [21,22]. This is achieved by thorough biomechanical preparation and shaping of root canal system [21,23]. Due to continuous introduction of new instruments by the manufactures, multiple researches must be done on the performance of these instruments to facilitate the decision making by clinicians [24].

The aim of the present study was to evaluate the shaping ability o of two rotary systems; HyFlex CM and HyFlex EDM rotary systems that were used in preparing natural curved root canals.

The HyFlex EDM and HyFlex CM systems are a martinsic NiTi file instruments subjected to a special heat treatment which resulted in production of a stable martensite structures at room temperature [25-27].

The HyFlex EDM is characterized by a variable cross section and a variable continuous taper; triangular near the handle, trapezoidal in the middle portion and rectangular at the tip where a .08 taper exists that reduces progressively up to .04 taper near the instrument handle [9,28,29]. On the other hand, HyFlex CM system has a symmetrical triangular cross-sectional design except for the instruments with size 25, .04 and 20, .04 taper, which have four flutes with a square cross section [25-27].

In this study, human natural teeth were used in agreement with many [13,30-36]. Human teeth have the privilege of simulating clinical conditions as irregular root canal anatomy, variable degrees of curvature and dentine [37-42]. Also, having a concave distal surface makes them more susceptible to strip perforation [43-45].

In this study, the working length was standardized to 15.5 mm for all samples to avoid any effect of root canal length on the final results [42,46]. The diameter of the apical root canal was matched to size [10-15] K files to permit identical apical canal preparations via any of the filling systems. The range of 25° - 45° is the selected angle of curvature in this study according to Schneider's method following other authors [40,47-53] due to its simplicity, accuracy and reliability [54].

Cone beam computed tomography was used to analyze the geometrical changes after root canal instrumentation. CBCT is characterized by high accuracy and three-dimensional imaging without destruction of the specimens, thus allowing better visualization of the anatomy producing geometrically accurate images and measurements free from any distortion [55]. OnDemand 3D App software was employed to superimpose preoperative and postoperative thus guaranteeing measuring dentin thickness at the exact root level with high accuracy and human free errors.

In the present study, Centering ability and Canal transportation were measured using the formulae proposed by Gambill., *et al*. [20] on the other hand the radius of curvature was calculated using the technique described by Estrela., *et al*. [3] as it is accurate, simple, reliable and had been employed in other studies [42,48,56].

Canal transportation is caused especially inside curved root canal as the rotary instrument to return tend straighten thus, more dentine is removed in a certain area inside the root canal. Centering ratio is the instrument ability to stay centered in the root canal during instrumentation. The value equal to 1 indicates perfect centering inside the root canal. During preparation, the instrument may deviate mesial or distal, removing dentin in those directions.

In the current study, measurements were done at three levels. The first level was at the apical third exactly at 3 mm from the apex where zipping and transportation often occurs [57,58]. While the middle and coronal thirds were represented by the 5 and 8 mm levels where stripping, especially distally at dangerous zone, may occur [59,60].

Knowing the radius of canal curvature allows us to overcome the anatomic limitations of the endodontic instruments and provides more accurate planning of root canal preparation. Change in radius of canal curvature is due to tendency of the canal curvature to be straightened [61-63]. The more the straightening of canal curvature due to the rotary instrument, the more the weakening of the tooth structure [64].

Wu., *et al*. [65] reported that the maximum apical transportation value would be 0.3 mm. In the present study, both systems were able to safely prepare the root canal as all the apical transportation values were less than 0.3.

Comparable results (less than 0.3 mm) for transportation were recorded previously for HyFlex EDM [13,30,31,33,66]. Similar results were found for HyFlex CM [67,68] although using larger sizes and taper but with the same design and manufacturing technique.

Canal transportation values reported in the HyFlex EDM group showed that significantly higher transportation at coronal (8 mm) level in comparison with the more apical levels (3 mm and 5 mm), These findings could be explained by continuous increase in the instrument size and metal bulk leading to decrease in the flexibility and increase in root canal transportation [9,23,69-73]. In HyFlex CM group, we found no statistically significant difference among the three levels.

While comparing the canal transportation value between the 2 groups, we found that the middle (5mm) level and the coronal (8 mm) level showed significant amount of transportation, while the (3mm) level showed no significant transportation between the 2 groups.

Regarding the middle (5 mm) level, the HyFlex EDM showed significantly less transportation due to that the HyFlex EDM file uses electrical discharge machining technology and has an asymmetrical cross-section design and taper thus, increasing the file flexibility and preserve the root canal anatomy [28,29,31,74]. However at coronal (8 mm) level, the HyFlex EDM showed significantly more transportation explained by that the HyFlex EDM has trapezoidal cross section which shows more increase in the instrument size, and metal core than the square cross section of the HyFlex thus, decreasing the file flexibility and increasing canal transportation [9,23,69-73].

Comparable results for the HyFlex EDM and HyFlex CM results group regarding canal transportation were consistent to those obtained by Razcha., *et al* [33]. The 3, 5 and 8 mm levels reading were almost similar to this study results.

Regarding the overall canal transportation results, no statistically significant difference was recorded between HyFlex EDM and HyFlex CM groups. This non-significant difference might be explained by the similarity between the instruments regarding thermo-mechanical processing, both utilizing same rotary motion, same apical size and presence of non-working tip [9,23,31,70-73].

Regarding the direction of canal transportation results, transportation in both direction; distal and mesial was revealed by the two rotary systems, but with no statistically significant differences. Comparable results regarding the direction of canal transportation was reported for the HyFlex EDM and HyFlex CM group by Pinheiro., *et al*. [30] at the 3 mm and the 5 mm level.

Overall the two groups showed most of transportation to be towards the distal direction. This may be attributed to MB canal having a concavity that exists on the distal aspect of the MB root [15,75,76] Comparable results regarding the overall canal transportation direction for the HyFlex EDM and HyFlex CM groups were obtained by Pinherio., *et al* [30].

The centering ability results revealed that both instruments couldn't stay centered perfectly inside the canal. There was no statistically significant difference between the two rotary systems at all levels. These findings were in agreement with Razcha., *et al*. [33] and Huang., *et al*. [66] comparable centering ability between the two instruments could be attributed to similarity regarding control memory technology, instrumentation technique and rotation motion as well as similarity in apical size, presence of non-cutting [9,23,31,70-73].

Comparable results for the HyFlex EDM and HyFlex CM group centering ability for all the 3 levels in this study were obtained by Razcho., *et al* [33]. The 3, 5 and 8 mm levels reading were almost similar to this study results.

Concerning change in radius of canal curvature it was found that no statistically significant difference recorded among the two groups. Both files changed the radius of canal curvature significantly after preparation. This could be due to progressive increases in the metal core and the increase of the tip diameter of the two rotary systems. This resulted in straightening of the canal curvature there by increasing the radius of curvature [9,70-73]. This significant increase comes in agreement with other researches that investigated NiTi rotary instrument [9,70-73].

Conclusion

Finally, we concluded that:

1. HyFlex EDM and HyFlex CM systems can safely prepare severely curved root canals
2. The two rotary systems showed acceptable canal transportation values.
3. None of the rotary systems were able to accomplish perfect centering ability while preparing severely curved root canals.
4. HyFlex CM has shown more straightening regarding the radius of curvature.

Recommendation

As this *in-vitro* study has shown that the two rotary systems were safe to use, it can be recommended to examine these systems in randomized clinical trials on patients for true end results such as post-operative pain and reduction in bacterial count.

Conflict of Interest

The authors deny any conflicts of interest in this study.

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