Section: Research Paper

A Comparative Evaluation of Four Rotary Pathfinding Instruments in Curved Canals of Mandibular Molars: Centering Ability and Canal Transportation-An Ex Vivo Study

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Abstract

Background: For the development of a glide route, using hand files has various benefits, including a reduced cost and a greater tactile sense. However, using these files wears out the operator, extends the time required for preparation, increases debris extrusion via the apical foramen, and modifies the root canal system's natural structure. The purpose of this study is to evaluate centering ability and canal transportation in curved canals of mandibular molars.

Aim & Objectives: Comparative evaluation of four rotary pathfinding instruments in curved canals of mandibular molars: centering ability and canal transportation- an Ex Vivo study

Materials and Method: This Ex Vivo experimental study was conducted on extracted human mandibular first and second molars (n=60) with moderately canal curvature in their mesiobuccal root. All teeth underwent CBCT and were randomly divided into four groups (n=15). In group 1, a glide path in the mesiobuccal canal was created using TruNatomy file system to the working length. In groups 2, 3 and 4, after canal negotiation, a glide path was created with M Two,

ProGlider, and Hyflex EDM system, respectively. The teeth underwent CBCT. Pre and postoperative CBCT scans were compared to calculate the magnitude of canal transportation at 1,2, and 3 mm from the apex.

Results: Overall there were no statistically significant differences in canal transportation between the file systems at 1mm, 2mm and 3mm from the apex There was higher mean centering ability in Hyflex EDM at 3mm from apex.

Conclusion: Higher mean centering ability was seen in hyflex when compared to Trunatomy at 3mm from the apex before the treatment and after the treatment ProGliderdiplays a lower mean centering ability when compared to TruNatomy and Hyflex at mesial and distal sides. No statistically significant differences were found in canal transportation between the file systems at 1mm, 2mm and 3mm from the apex.

Keywords: Glide path, Trunatomy, Hyflex, ProGlider, M Two, Centering ability, canal transportation

Introduction

Debridement, disinfection, and obturation of the entire root canal system are required for successful root canal therapy.[1] Phases of endodontic therapy such as cleaning and contouring of the root canals are crucial. Debridement of the entire root canal system, creation of a constantly tapering funnel-shaped channel, and preservation of the original root canal system shape are among the goals of instrumentation.[2] The key components of a successful procedure are adequate cleaning, shape, and creation of a coronal seal, with obturation being less crucial for immediate success.[3] Dentin chips created by instrumentation and pieces of apical pulp tissue have a tendency to become compressed into the foramen during root canal preparation, which can obstruct the working length and lead to apical occlusion. NiTi rotary instruments which have a lower modulus of elasticity than stainless steel instruments and so exert fewer lateral forces on the dentin walls in the curved canals, revolutionized endodontics. The elastic limit of NiTi instruments allows for fractures even if they are stronger and more flexible than stainless steel counterparts.[4,5] However, using these files wears out the operator, extends the time required for preparation, increases debris extrusion via the apical foramen, and modifies the root canal system's natural structure. The root canal preparation process can be completed more quickly, with less technical sensitivity and postoperative pain because to the use of rotary files to create a glide path.[6,7] A recent NiTi rotary system called TruNatomy (TN; Dentsply Sirona, Maillefer, Ballaigues, Switzerland) was shown. The majority of generic files are made from 1.2mm NiTi wire, while this file system is made with 0.8mm NiTi wire, which exhibits an off-centered parallelogram cross section. One of the earliest endodontic instruments made using EDM technology is the Hyflex EDM file. Three different cross section patterns are arranged in a single file. More "core material" is provided by the rectangular cross section at the tip, giving these files a strong resistance to breaking. The cross section then shifts to trapezoidal at the middle of the file, and finally, to triangular near the handle, maintaining the file's flexibility there.

Aim and Objectives

The aim of this study is to comparatively evaluate four rotary pathfinding instruments in curved canals of mandibular molars: Centering ability and Canal transportation- an Ex Vivo study. Objectives were to compare centering ability and Canal transportation of four pathfinding rotary instruments in curved canals of mandibular molars with CBCT.

Materials and Methodology

A total of sixty freshly extracted human mandibular first and second molars with curved roots are chosen for this study. Teeth with open apex, resorption, root fractures and calcified canals are excluded from the study. The collected teeth are stored in 5.25% sodium hypochlorite solution for 30 seconds for surface disinfection and to remove the organic debris away from the root surface. Conventional access cavity is prepared and a 10k file was placed into the mesiobuccal canal until the tip of the file was visible at the apical foramen and working length was established 0.5-1mm short from this length. The teeth are divided into 4 experimental groups and scanned by using Cone Beam Computed Tomography (CBCT) to determine the degree of root canal curvature. The radius of root curvature is determined through CBCT measured by the circumcenter using Galexis Galileos software based on three mathematical points. Two semi straight lines of 6mm are drawn and the mid points of the lines are determined. Perpendicular lines from the midpoint of each primary semi straight lines are drawn until they meet at a central point that is termed the circumcenter. The distance between the circumcenter and the mid point of each semi straight line will actually determine the magnitude of the canal curvature. The smaller the radius, the greater the curvature and thus more complex the root canal structure. The samples (n=60) were divided depending on the rotary instruments used into 4 groups. Group 1 has 15 teeth were prepared using ProGlider file system (16/0.02 at speed of 300 rpm, 1.2N/cm torque). Group 2 has 15 teeth were prepared using MTwo file system (10/0.04 at speed of 300 rpm, 1.2 N/cm torque). Group 3 has 15 teeth were prepared using Hyflex EDM file system (10/0.02 at speed of 300 rpm, 1.2 N/cm torque). Group 4 has 15 teeth were prepared using TruNatomy file system (13/0.02 at speed of 500 rpm and 1.5 N/cm torque). The instruments were inserted into the curved canals gently accompanying with 3mm amplitude limit and up and down pecking motion. During instrumentation, the canal is irrigated with 2.5% sodium hypochlorite solution (2ml). When root canal instrumentation is completed, 1ml of 15% EDTA is applied for 1min and the canal flushed again with 3ml of NaOCl and the canal is dried with absorbent paper points. After root canal preparation, teeth are then scanned under the same conditions. CBCT scan was prepared with the similar exposure parameters and axial pitch and thickness after instrumentation. The acquired pre and postoperative images are exported to Galexis Galileos Software and measurements are accomplished using AutoCAD software program. The following formula was utilized for calculation the transportation in both mesio-distal and buco-lingual directions at each root canal level as follows: Mesiodistally: (M1-M2)-(D1-D2) Buccolingually: (B1-B2)- (L1-L2). The Result Zero of the equation means no

transportation, while the positive results indicate (mesial/buccal) transportation, and the negative results indicate (distal/lingual) transportation. The results of the equations with the lowest numerator were used. If the result was equal one, it indicated perfect centering ability, while if the result was less than one, this indicated less centering ability (i.e. the less ability of the instrument to keep centralized inside the canal).

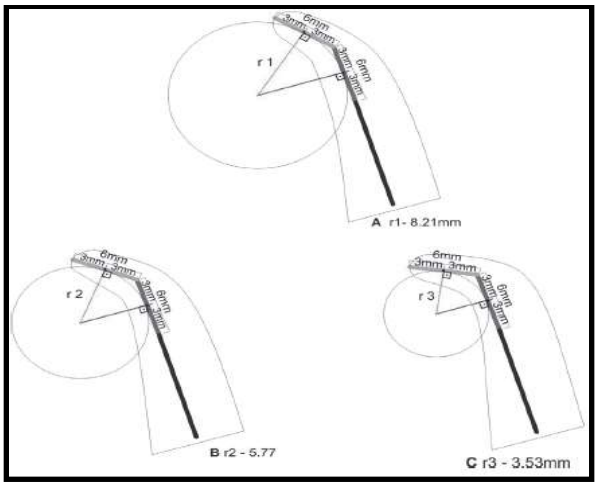


Figure 1: The root curvature radius based on 3 mathematical points can be determined in both apical and coronal directions. Curvature radius considering the two 6-mm semistraight lines are classified as small radius (r≤4mm): severe curvature; intermediary radius (r≥4 and 4≤8mm): moderate curvature; and large radius (r≥8 mm): mild curvature

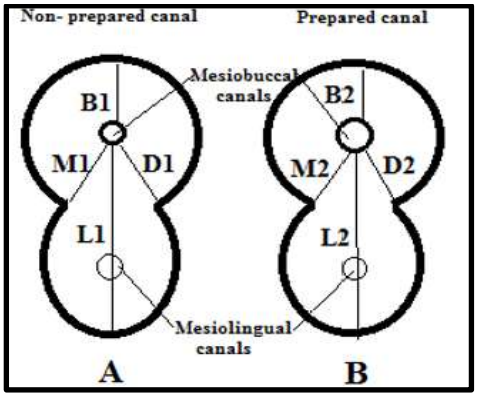


Figure 2: Diagram showing canal transportation and centering ability evaluation based on Gambill's formula; the cross-section of non-prepared canal (A) and prepared canal (B). M1, B1, L1 and D1are dentin thickness before instrumentation, while M2, B2, L2 andD2 are dentin thickness after instrumentation

Figure 3: Teeth mounted in silicone based impression material

Figure.4: Scanning of the tooth sample

Results

For Trunatomy File System; Paired sample t test displays that there is a statistically significant higher mean cantering ability were noted among Pre-treatment group of the Mesial (P=0.349) and distal (P=0.17) tooth root at 1mm from the apex when used TRUNATOMY system. Paired sample t test displays that there is a statistically significant higher mean centering ability were noted among Post treatment group of the Mesial (P=0.01) and Lingual (P=0.001) tooth root at 2mm from the apex when used TRUNATOMY system. Paired sample t test displays that there is a statistically significant higher mean centering ability were noted among Post treatment group of the Distall (P=0.039), Buccal (P=0.005) and Lingual (P=0.007) tooth root at 3mm from the

apex when used TRUNATOMY system. For Hyflex Edm File System, paired sample t test displays that there is a statistically significant higher mean centering ability were noted among Post treatment group of the Lingual tooth root at 1mm from the apex when used HYFLEX EDM system. Paired sample t test displays that there is a statistically significant higher mean centering ability were noted among Pretreatment group of the Lingual (P=0.01) tooth root at 2mm from the apex. Paired sample t test displays that there is a statistically significant higher mean centering ability were noted among Pretreatment group of the Lingual and Buccal tooth root at 3mm from the apex. For M Two File System; paired sample t test displays that there is a statistically significant higher mean centering ability were noted among Post treatment group of the Buccal and Lingual tooth root at 1mm from the apex when used M Two system. Paired sample t test displays that there is a statistically significant higher mean centering ability were noted among Pretreatment group of the Lingual (P=0.029) tooth root at 3mm from the apex. For Proglider File System; paired sample t test displays that there is no statistically significant difference in mean centering ability among PROGLIDER, groups among Mesial, Distal, Buccal and Lingual side of the root at 1mm, 2mm and 3mm from the apex.

Table 1: Pair wise comparison of mean centering ability of Trunatomy among Mesial, Distal, Buccal and Lingual side of the root at 1mm, 2mm and 3mm from the apex

				N	Mean	SD	P Value
Trunatomy	1mm from Apex	Mesial	Pre	15	0.94	0.14	0.349
			Post	15	0.89	0.17	
		Distal	Pre	15	0.97	0.20	0.178
			Post	15	0.91	0.15	
		Buccal	Pre	15	0.91	0.16	0.396
			Post	15	0.86	0.11	
		Lingual	Pre	15	0.92	0.17	0.29
			Post	15	0.85	0.14	
	2mm from Apex	Mesial	Pre	15	0.80	0.08	0.01*
			Post	15	0.95	0.15	
		Distal	Pre	15	0.94	0.08	0.86
			Post	15	0.95	0.12	
		Buccal	Pre	15	0.85	0.14	0.067
			Post	15	0.97	0.16	
		Lingual	Pre	15	0.79	0.06	<.001*
			Post	15	0.93	0.11	
	3mm from Apex	Mesial	Pre	15	0.91	0.14	0.144
			Post	15	1.00	0.17	

		Distal	Pre	15	0.93	0.13	0.039*
			Post	15	1.06	0.14	
		Buccal	Pre	15	0.92	0.15	0.005*
			Post	15	1.09	0.16	
		Lingual	Pre	15	0.92	0.07	0.007*
			Post	15	1.07	0.17	

Table 2: Pair wise comparison of mean centering ability of HYFLEX EDM, groups among Mesial, Distal, Buccal and Lingual side of the root at 1mm, 2mm and 3mm from the apex

				N	**Mean**	**SD**	**P Value**
Hyflex EDM	1 mm from Apex	Mesial	Pre	15	0.85	0.12	0.349
			Post	15	0.87	0.15	
		Distal	Pre	15	0.88	0.11	0.178
			Post	15	0.89	0.19	
		Buccal	Pre	15	0.87	0.15	0.396
			Post	15	0.87	0.23	
		Lingual	Pre	15	0.85	0.13	0.29
			Post	15	0.87	0.12	
	2 mm from Apex	Mesial	Pre	15	0.93	0.17	0.681
			Post	15	0.91	0.14	
		Distal	Pre	15	0.98	0.13	0.029
			Post	15	0.87	0.13	
		Buccal	Pre	15	0.95	0.12	0.373
			Post	15	0.91	0.13	
		Lingual	Pre	15	1.04	0.10	**<.001***
			Post	15	0.89	0.16	
	3 mm from Apex	Mesial	Pre	15	0.96	0.14	0.389
			Post	15	1.02	0.19	
		Distal	Pre	15	0.99	0.15	0.916
			Post	15	0.98	0.15	
		Buccal	Pre	15	1.07	0.13	0.076
			Post	15	0.97	0.14	
		Lingual	Pre	15	1.03	0.13	0.486
			Post	15	0.99	0.17	

Table 3: Pair wise comparison of mean centering ability of M Two, groups among Mesial, Distal, Buccal and Lingual side of the root at 1mm, 2mm and 3mm from the apex

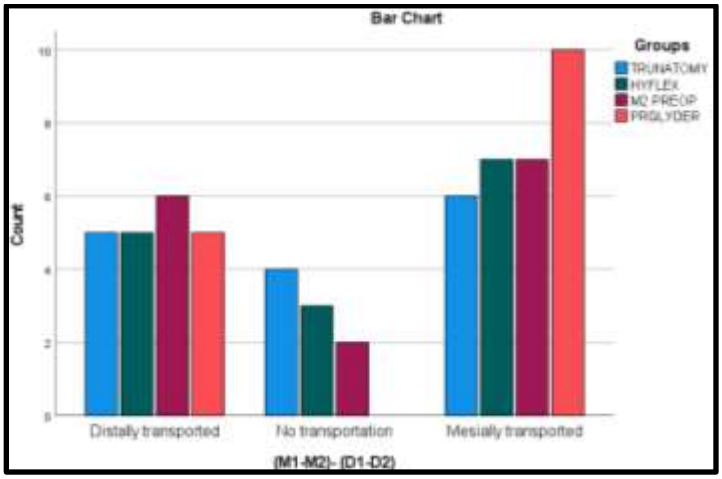
				N	Mean	SD	P Value
M Two	1 mm from Apex	Mesial	Pre	15	0.72	0.15675	0.452
			Post	15	0.7733	0.27894	
		Distal	Pre	15	0.8267	0.14864	0.712
			Post	15	0.8533	0.23563	
		Buccal	Pre	15	0.84	0.22297	0.509
			Post	15	0.8867	0.23865	
		Lingual	Pre	15	0.8267	0.17099	0.324
			Post	15	0.8733	0.1831	
	2 mm from Apex	Mesial	Pre	15	0.8533	0.14075	0.651
			Post	15	0.82	0.22741	
		Distal	Pre	15	0.9533	0.21668	1
			Post	15	0.9533	0.14573	
		Buccal	Pre	15	0.9467	0.18074	0.45
			Post	15	0.9067	0.08837	
		Lingual	Pre	15	0.8933	0.13345	0.784
			Post	15	0.9067	0.24044	
	3 mm from Apex	Mesial	Pre	15	0.92	0.15675	0.623
			Post	15	0.8933	0.15796	
		Distal	Pre	15	0.9667	0.13973	0.589
			Post	15	0.94	0.17647	
		Buccal	Pre	15	1.0067	0.13345	0.06
			Post	15	0.8867	0.13558	
		Lingual	Pre	15	0.9867	0.14573	**0.029***
			Post	15	0.8467	0.16417	

Table 4: Pair wise comparison of mean centering ability of PROGLIDER, groups among Mesial, Distal, Buccal and Lingual side of the root at 1mm, 2mm and 3mm from the apex

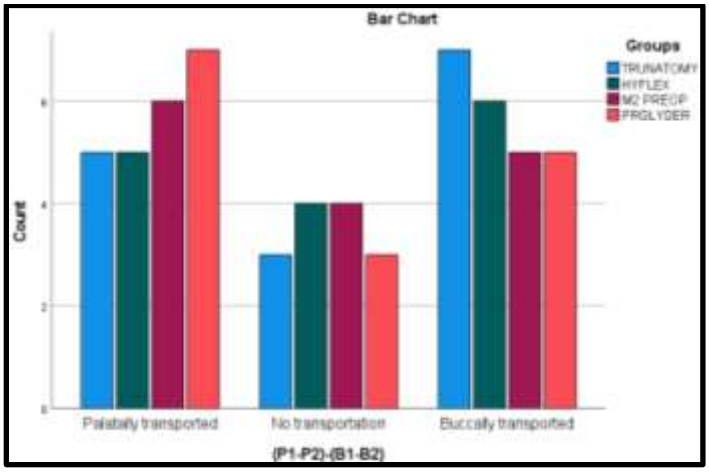
				N	Mean	SD	P Value
Proglider	1 mm from Apex	Mesial	Pre	15	0.86	0.19198	0.592
			Post	15	0.82	0.24842	
		Distal	Pre	15	0.88	0.10823	0.519
			Post	15	0.9133	0.19591	
		Buccal	Pre	15	0.9067	0.12799	0.077

			Post	15	0.8333	0.1543	
		Lingual	Pre	15	0.8733	0.15337	0.571
			Post	15	0.84	0.22297	
	2 mm from Apex	Mesial	Pre	15	0.8933	0.15337	0.505
			Post	15	0.9333	0.1633	
		Distal	Pre	15	0.84	0.09856	0.638
			Post	15	0.86	0.11212	
		Buccal	Pre	15	0.88	0.10823	0.628
			Post	15	0.9067	0.16676	
		Lingual	Pre	15	0.96	0.15024	0.318
			Post	15	0.9067	0.11629	
	3 mm from Apex	Mesial	Pre	15	0.8933	0.15337	0.505
			Post	15	0.9333	0.1633	
		Distal	Pre	15	0.84	0.09856	0.638
			Post	15	0.86	0.11212	
		Buccal	Pre	15	0.88	0.10823	0.628
			Post	15	0.9067	0.16676	
		Lingual	Pre	15	0.96	0.15024	0.318
			Post	15	0.9067	0.11629	

Graph 1: Depicts transportation of Trunatomy, Hyflex EDM,M Two, Proglider among mesial and distal sides (1mm from apex)



Graph 2: Depicts transportation of Trunatomy, Hyflex EDM,M Two, Proglider among Buccal and lingual sides (1mm from apex)



Discussion

Curvatures may make it difficult to properly instrument a root canal. The most frequent unfavorable incidents that can happen during the formation of curved root canals are deviations and apical transportation. There are many file systems on the market that claim to retain the canal anatomy and are based on various Ni Ti wire technologies. Ni Ti tools are well known for their benefits in the preparation of root canals.[8,9] However, a number of complicated interrelated factors, including the cross-sectional design, helical and rake angles, metallurgical characteristics, and surface treatments of the instrument, affect their cutting capacity. A recent NiTi rotary system called Trunatomy was unveiled. The M Two instrument has an S-shaped cross-sectional design with a double cutting blade non cutting safety tip and positive cutting angle.[10,11] Electrical Discharge Machining is referred to as EDM. This is a distinctive method of processing the files utilizing electric discharge machining. In the EDM manufacturing process, work pieces are machined by creating a potential between the work piece and the tool. The material's surface melts and evaporates as a result of the sparks produced during this process. This gives the new Niti files their distinctive surface and strengthens and increases the fracture resistance of the Hyflex EDM files. One of the earliest endodontic instruments made using EDM technology is the Hyflex EDM file.[12,13] Recently, a new NiTi wire termed M-Wire technology has been developed through a proprietary thermomechanical processing procedure. This type of NiTi raw material suggests significantly improved fatigue resistance of endodontic rotary instruments in comparison with those made of conventional superelastic NiTi alloys. The stiffness of the file during canal preparation causes transportation of the canal to happen. Because of the uneven distribution of forces caused by this, the file inside the canal straightens at the canal's curvature. The files tend to straighten and return to their former shape on the outside curve of the apical portion of the root canal during canal preparation. In this study, CBCT is used to evaluate canal transportation and centering ability.[14-19] One of the latest innovations in the medical field is CBCT for study purposes, and this scientific tool could develop potential in endodontic research. Additionally, these studies demonstrate that evaluating root canal

instrumentation is an accurate and effective procedure thanks to the quality of the three-dimensional pictures produced by CBCT scanning.[20-25] The present study evaluated four rotary Ni-Ti file systems for their shaping ability, namely, Trunatomy (TN), ProGlider, MTwo and Hyflex EDM and compared the canal transportation and centering ability of these files with the help of CBCT. The present investigation was based on the latest innovations in the medical field i.e. CBCT, for the evaluation of canal transportation and centering ability of tested instruments. Performing measurements at three levels from the apex to the canal orifice is a well known methodology to evaluate the canal transportation and centering ability in the apical, middle and coronal third where the risk of procedural errors is higher.[26-28] On comparison, the mean centering ability of Trunatomy and Hyflex EDM file systems it was observed that higher mean centering ability were noted among post treatment groups of Trunatomy among distal, buccal and lingual at 3mm from apex whereas there was a higher mean centering ability among pretreatment groups of Hyflex EDM in lingual ($p=0.01$) tooth root at 2mm from apex. It is also seen that higher mean centering ability were seen in M Two file systems among the pretreatment group of the lingual ($P=0.029$) tooth root at 3mm from Apex whereas it is also observed that there is no statistically significant difference in mean centering ability among ProGlider groups among mesial, distal, buccal and lingual side of the root at 1,2,3 mm at apex. As shown, there was no statistically significant difference distally, mesially, lingually, buccally and there was no transportation between all the groups at 1mm, 2mm, 3mm from the apex. The null hypothesis that there would be no difference between the systems and the variables under study was partially rejected. The present study shows, at the level of 6mm Trunatomy (TN) and Neohybrid (NH) files of 4% taper recorded significantly less transportation when compared with ProTaper Next (PTN) file system of 6% taper. Trunatomy (TN) file system has shown a significant difference in minimal transportation compared to ProTaper Next (PTN) file system, and it had stated that Trunatomy (TN) instruments safeguard the structural dentin and tooth integrity due to their instrument geometry, regressive tapers, and slim design, along with the heat treatment of the NiTi alloy. It is necessary to conduct additional research on additional NiTi files utilized for canal negotiation and glide route formation. Future research should also look on transportation in curved canals. Last but not least, when it comes to canal transportation, rotary NiTi files must be compared with hand NiTi files.

Conclusion

It is concluded that higher mean centering ability was seen in Hyflex EDM when compared to Trunatomy at 3mm from the apex before the treatment and after the treatment Proglider displays a lower mean centering ability at the mesial, distal, buccal and lingual sides when compared to Trunatomy, Hyflex EDM, M Two file systems. Overall there were no significant differences in canal transportation between the file systems at 1mm, 2mm and 3mm from the apex.

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