ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)
IJDSIR : Dental Publication Service
Available Online at: www.ijdsir.com
Volume – 4, Issue – 5, October - 2021, Page No. : 96 - 101

Comparative Evaluation of Canal Transportation and Canal Centering Ability of three different continuous Nickel Titanium Rotary File Systems using Cone Beam Computed Tomography: An In Vitro Study

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Citation of this Article: Dr. Arthanareswaran Andamuthu Sivakumar, Dr. M. Chittrarasu, Dr. Saranya Sivara, "Comparative evaluation of canal transportation and canal centering ability of three different continuous nickel titanium rotary file systems using cone beam computed tomography: an in vitro study", IJDSIR- October - 2021, Vol. – 4, Issue - 5, P. No. 96 – 101.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background: To compare the Canal transportation and Canal centering ability and evaluate the efficacy of three different continuous Nickel-titanium rotary systems (EdgeTaper, ProTaper Gold, Hyflex EDM) to prepare curved canals using CBCT.

Materials and Method: Total of thirty permanent mandibular molars were taken for study, endo access bur was used to open the access and the distal roots with corresponding crown portions were sectioned and discarded. According to Schneider's methodology, canal curvature was examined using CBCT to evaluate the root canal shape before instrumentation and then randomly divided into three groups with 10 specimens each. CBCT was used to determine the root canal shape following cleaning and shaping protocol at 3 mm,6 mm and 9 mm after instrumentation.

Statistical analysis: Ata were analyzed using the Kruskal Wallis test.

Results: At 3 mm, Edge taper showed lesser transportation, whereas at 6mm and 9mm, Protaper Gold showed lesser transportation.

Conclusion: Compared to the other two files, canals prepared with Protaper Gold showed minimal root canal transportation and had a better centering ability.

Keywords: Canal Transportation, CBCT, Centering ability, Heat treated NiTi files.

Keymessage: Canal transportation and Canal centering ability evaluated by different continuous NiTi rotary systems using CBCT at 3mm, 6mm and 9mm resulted that at 3 mm Edge taper and at 6 mm and 9 mm Protaper Gold showed lesser transportation.

Introduction

The most critical step in root canal treatment is removing bacteria and preserving the radicular anatomy during cleaning and shaping. [1] The success of all subsequent procedures, including chemical disinfection and root canal obturation, is determined by root canal shape, which is one of the most vital phases in root canal treatment. [2] Furthermore, shaping tends to preserve the integrity and location of the canal. However, in some cases, overshaping leads to excessive removal of residual dentin thickness, which weakens the root structure and leads to procedural errors such as zipping, ledge formation, and transportation.[3] Endodontic treatment of curved root canals remains difficult for endodontic practitioners, despite the numerous preparatory measures created to avoid these problems. [4] Since the introduction of nickel-titanium (NiTi) rotary instruments in the 1990s, studies have shown that these instruments maintain original canal shape and allow for a safer, more rapid, more centered, and easier preparation of severely curved root canals. [5]

Canal transportation is defined as excessive dentine loss in a single direction within the canal rather than in all directions equidistantly from the central tooth axis. Canal centering ability is defined as keeping the instruments centered on providing a correct enlargement without weakening the root structure. [6]

With time, many NiTi instrument systems with different features have been introduced. One among them is Edge Taper which is an endodontic instrument made of Fire-Wire, a heat-treated NiTi alloy[7] that increases file flexibility, flexural strength, and cyclic fatigue resistance, which has a rectangular cross-section with variable taper.[8] Heat treatment technology using proprietary advanced metallurgy has lead to the development of the Protaper gold system.[9] It features a progressively tapered design that claimed to improve cutting efficiency and safety. HyFlex EDM is 5th generation root canal files, which have completely new properties due to their innovative manufacturing process using electric discharge machining (EDM).[10] The cross-sectional design is variable, rectangular towards the tip and triangular towards the shaft.

Histological sections, plastic models, serial sectioning, scanning electron microscopy, radiographic comparisons, silicone impressions of instrumented canals, and micro-computed tomography (CT) were employed to evaluate shaping ability. However, Cone-beam computed tomography (CBCT) imaging, on the other hand, has been used in this study to give three-dimensional evaluation without destroying the tooth, making it a noninvasive approach for evaluating canal geometry and the efficacy of shaping procedures. [11]

No other studies have compared the centering ability and canal transportation of these new NiTi systems to the best of our knowledge. Hence, this study aimed to compare the Canal transportation and Canal centering ability and evaluate the efficacy of three different continuous rotary systems (Edge Taper, ProTaper Gold, Hyflex EDM) in preparing curved canals using CBCT. The null hypothesis states that no difference exists

between the three different rotary systems in canal transportation and canal centering ability when assessed by CBCT.

Materials and Methods

A total of thirty extracted human permanent mandibular molars with an adequate length of 20-21 mm were taken cleaned for tissue fragments and calcified debris and stored in formalin solution. Inclusion criteria included extracted teeth with no external or internal pathological root resorption and presence of apical closure and exclusion criteria included presence of pathological root resorption, severe root angulation, and immature tooth. The ethical clearance reference number is VDCW/IEC/204/2019. Endo-access bur was used to gain access to the pulp chamber, and a DG 16 probe was used to determine and explore the mesiobuccal canals. To determine canal curvature Schneider's methodology was used, and radiographs were taken to assess. Moderately curved roots (curvature angles ranging from 10° to 20°) were included. In this method a midpoint is marked on the file at the level of the canal orifice and a straight line parallel to the image is drawn and marked as point A.Next, point B is where the flare begins to depart. Finally, at the apical foramen, a third point called point C is indicated, and the angle generated by the junction of these lines is measured. According to the degree of root canal curvature, the obtained angle will be :

Straight < 5˚, Moderate 10˚- 20˚ and Severe 25˚ -70˚.

The distal half of the tooth was sectioned and discarded. Then, the working length determination was performed radiographically by inserting #15 K-file to the root canal terminus and subtracting 1 mm. According to the rotary systems employed, thirty samples were randomly divided into three groups, each with 10 specimens.

Group I - Edge Taper Rotary system (Edge Endo, USA)

Group II - ProTaper Gold Rotary system (Dentsply Sirona, USA)

Group III - Hyflex EDM Rotary system (Coltene, Switzerland)

All the samples were mounted in a resin block and scanned using CBCT to determine the root canal shape before instrumentation. During and after each preparation, all instrumented canals were irrigated with 10 ml of 2.5 % NaOCl. Then 3 ml of 17 % EDTA and 1 ml of saline was used for all canals. A CBCT scan was performed after instrumentation to examine canal morphology. iRYS viewer version 5.6 (Sirona Dental System) was used to evaluate both pre and post instrumented CBCT images. In both the mesial and distal directions, the shortest distance from the canal wall to the external root surface were measured on the reconstructed 2-dimensional image without reduction using the measure length tool at 3 mm, 6 mm and 9 mm.[12] Measurements were recorded before and after instrumentation to calculate the files apical transportation and centering ability, if any.

The following formula is used for the calculation of canal transportation :

(A1–A2) - (B1–B2)

A1-Shortest distance from the mesial edge to uninstrumented canal

A2-Shortest distance from the mesial edge to an instrumented canal

B1-Shortest distance from the distal edge to uninstrumented canal

B2- Shortest distance from the distal edge to instrumented canal [13]

According to this formula,

0 - No canal transportation.

Other than 0 -Transportation occurred.

The following formula is used for the calculation of centering ability :

(A1 − A2)/(B1 − B2) or (B1 − B2)/(A1 − A2).

A result of 1 indicates perfect centering according to this formula. [14]

Statistical Analysis: For statistical evaluation SPSS version 25.0 was used and to compare the study groups, Kruskal Wallis test was utilised. A p-value of less than 0.05 was considered to be statistically significant.

Results

At the 3 mm level, Group I (0.11) showed the lowest canal transportation, followed by Group II (0.14) and Group III (0.43). No statistically significant difference was present between group I and Group II, whereas Group III was significantly different compared to the other two groups.

At the 6 mm level, Group II (0.08) showed the lowest canal transportation, followed by Group I (0.18) and Group III (0.39). There was a statistically significant difference between all three groups.

At the 9 mm level, Group II (0.02) showed the lowest canal transportation, followed by Group III (0.11) and Group I (0.25). There was a statistically significant difference between all three groups.

At the 3 mm level, Group I (2.94) showed the highest canal centering ability, followed by Group III (2.87) and Group II (1.75). No statistically significant difference was present between group I and group III, whereas Group II was significantly different compared to the other two groups.

At the 6 mm level, Group II (2.88) showed the highest canal centering ability, followed by Group III (1.40) and Group I (0.42). There was a statistically significant difference between all three groups.

At the 9 mm level, Group II (1.31) showed the highest canal centering ability, followed by Group III (0.99) and Group I (0.70). No statistically significant difference was present between all three groups.

At level 3mm, Edge Taper showed lesser transportation, and at levels 6mm and 9mm, Protaper Gold showed lesser transportation and remained better centered in the canal than Edge Taper and Hyflex EDM files.

Discussion

Preservation of apical root canal morphology and avoiding apical transportation would result in a well-sealed root filling with less extrusion of debris and diminished postoperative discomfort.[15] Studies have reported that maintaining the original canal shape with a less invasive method decreases the possibility of canal transportation with a subsequently lower incidence of canal straightening, the formation of ledges, and irregular apical enlargement.[16] Three levels (3mm, 6mm, and 9 mm from the root apex) are chosen in this study becaause they reflect the apical and middle thirds of the root canal, where iatrogenic errors are most common.

CBCT is the most often utilised method to study canal transportation and centering ability because it is reproducible and permits the recording of multiple images, and also offers detailed information inspite of several approaches.[17] By using CBCT, it becomes possible to compare the anatomic structure of the root canal before and after root canal preparation.

In the current study, root canal transportation was minimum at 3mm by Edge Taper due to increased flexibility and resistance to cyclic fatigue. And at 6 mm and 9mm, Protaper gold showed lesser canal transportation, this can be attributed to Protaper Gold's design system, which had been metallurgically strengthened through heat treatment technology, which imparts a lower restoring force and may explain why they

remain more centered in the canal than other files.[18] Protaper Gold files also exhibit convex triangular cross-sections and progressively tapered designs that improve cutting efficiency and safety. [19] As a result, the null hypothesis had been invalidated.

Silva et al., in 2015 did a similar study on the Comparison of canal transportation in simulated curved canals prepared with ProTaper Universal and ProTaper Gold systems and found similar results that the Protaper Gold system produced overall less canal transportation in the curved portion when compared to the Protaper Universal system.[20]

Amr M Elnaghy et al., in 2014, did an in vitro study on shaping the ability of ProTaper Gold and ProTaper Next using CBCT and stated that there was no significant difference in the two groups and had similar shaping ability in root canal preparation.[21]

Arslan et al., in 2017, did a comparative study to assess root canal transportation, centering ability, and instrumentation time using the ProTaper Gold, Reciproc, and ProTaper Universal using cone-beam computed tomography (CBCT). In the results, he stated no significant difference was seen in the transportation of root canal and centering ratio compared to the ProTaper Universal and Reciproc; the ProTaper Gold demonstrated similar root canal transportation and centering ratio.[22]

Table 1: Distribution of mean and standard deviation values of canal transportation at 3, 6 and 9 mm from the apex

Canal Transportation	GROUP 1			GROUP 2			GROUP 3			p-value
	Edge taper			Protaper gold			Hyflex EDM			
	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median	
3 mm	0.11	0.35	0.19	0.14	0.43	0.09	0.43	0.41	0.325	0.038*
6 mm	0.18	0.16	0.19	0.08	0.43	0.065	0.39	0.34	0.46	0.051
9 mm	0.25	0.41	0.445	0.02	0.33	0.01	0.11	0.22	0.04	0.067
p-value	0.037*			0.893			0.001*			

Significant; SD: Standard Deviation

Table 2: Distribution of mean and standard deviation values of canal centering ability at 3, 6 and 9mm from the apex.

Centering ability	Group 1			Group 2			Group 3			p-value
	Edge taper			Protaper gold			Hyflex EDM			
	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median	
3 mm	2.94	6.05	0.7756	1.75	1.75	1.6192	2.87	4.43	1.5682	0.076
6 mm	0.42	0.67	0.0789	2.88	4.89	2.2321	1.4	5.97	0.3062	0.345
9 mm	0.7	0.95	0.2417	1.31	2.64	0.4286	0.99	2.02	0525	0.822
p-value	0.245			0.611			0.406			

Conclusion

Within the scope of this study, it was possible to conclude that all of the evaluated files showed some degree of canal transportation, but it was well within the permissible range. In addition, Protaper Gold showed lesser transportation and remained better centered than Edge Taper and Hyflex EDM files due to its progressively tapered design and reduced restoring force.

References

1. Moghaddam KN, Mehran M, Zadeh HF. Root canal cleaning efficacy of rotary and hand files instrumentation in primary molars. Iran Endod Journal 2009; 4:53-7
2. Berutti E, Chiandussi G, Paolino DS, Scotti N, Cantatore G, Castellucci A, et al. Canal shaping with WaveOne primary reciprocating files and ProTaper system: A comparative study. JOE 2012; 38:505-9.
3. Tambe VH, Nagmode PS, Abraham S, Comparison of canal transportation and centering ability of rotary ProTaper, one shape system and WaveOne system using cone-beam computed tomography: An in vitro study. J Conserv Dent 2014; 17:561-5.
4. Hulsmann M, Peters OA, et al. Mechanical preparation of root canals shaping goals, techniques, and means. Endod Topics 2005; 10:30–76.
5. Bergmans L, Van Cleynenbreugel J, Wevers M, Lambrechts P et al. Mechanical root canal preparation with NiTi rotary instruments: Rationale, performance and safety. American Journal of Dentistry 2001; 14:324–33
6. Nagaraja S, Sreenivasa Murthy BV. CT evaluation of canal preparation using rotary and hand Ni-Ti instruments: An in vitro study. J Conserv Dent 2010; 13:16-22
7. Bueno, Cury, Vasques, Sivieri-Araujo,Jacinto,Gomes-Filho,et al. Cyclic fatigue resistance of novel Genius and Edge file nickel-titanium reciprocating instruments. Braz.Oral Res 2019;33:28-33.
8. Yılmaz, Eren, Badi, Ocak, et al. Evaluation of the Amount of Root Canal Dentin Removed and Apical Transportation Occurrence after Instrumentation with ProTaper Next, OneShape, and EdgeFile Rotary Systems. JOE 2020; 46:662–667.
9. Ruddle CJ. Shaping complex canals: Clinical strategy and technique. Dent Today 2014; 33:88-95
10. Pirani C, Iacono F, Generali L, Sassatelli P, Lusvarghi L, Gandolfi M.G, et al. HyFlex EDM: superficial features, metallurgical analysis and fatigue resistance of innovative electro-discharge machined NiTi rotary instruments. Int Endod J 2016; 49:483-93.
11. Gluskin AH, Brown DC, Buchanan LS. A reconstructed computerized tomographic comparison of Ni-Ti rotary GT files versus traditional instruments in canals shaped by novice operators. Int Endod J 2001; 34:476-84.
12. Pratima et al.Comparative Evaluation of Shaping Ability of V-Taper 2H, ProTaper Next, and HyFlex CM in Curved Canals Using Cone-beam Computed Tomography: An In Vitro Study. Indian Journal of Dental Research 2017;28:181-6.
13. Gambill JM, Alder M, et al. Comparison of nickel-titanium and stainless steel hand-file instrumentation using computed tomography. JOE 1996; 22:369-75.
14. Pagliosa A, et al Computed tomography evaluation of rotary systems on the root canal transportation and centering ability. Braz Oral Res 2015;29.
15. Thota et al. Comparative evaluation of canal shaping ability of three nickel-titanium instrument systems using cone-beam computed tomography: An in vitro study. Endodontology 2017; 29:120-4.

16. Loizides AL, Kakavetsos VD, Tzanetakis GN, Kontakiotis EG, Eliades G. A comparative study of the effects of two nickel-titanium preparation techniques on root canal geometry assessed by microcomputed tomography. Journal Of Endodontics 2007; 33:1455-9.
17. Hartmann MS, Barletta FB, Camargo-Fontanella VR, Vanni JR. Canal transportation after root canal instrumentation: A comparative study with computed tomography.Journal Of Endodontics 2007;33:962-5.
18. Perez-Higueras JJ, Arias A, et al. Differences in cyclic fatigue resistance between ProTaper Next and ProTaper Universal instruments at different levels.Journal Of Endodontics 2014;40:1477–81.
19. Hieawy A, Haapasalo M, Zhou H, et al. Phase transformation behavior and resistance to bending and cyclic fatigue of ProTaper Gold and ProTaper universal instruments. Journal Of Endodontics 2015; 41:1134–8.
20. Silva EJ, Tameirao MD, Belladonna FG, Neves AA, Souza EM, De-Deus G et al. Quantitative transportation assessment in simulated curved canals prepared with an adaptive movement system. Journal Of Endodontics 2015; 41:1125-1129.
21. Elnaghy AM, Elsaka SE. Evaluation of root canal transportation, centering ratio and remaining dentin thickness associated with ProTaper next instruments with and without glide path. Journal Of Endodontics 2014; 40:2053-2056.
22. Arslan H, Yildiz E, Gunduz H, et al. Comparative study of ProTaper gold, reciprocal, and ProTaper universal for root canal preparation in severely curved root canals. J Conserv Dent 2017;20:222-224.