



Research Article

Assessment of Canal Centering Ability and Canal Transportation of Protaper Universal, Protaper next and Twisted Files Using Cone Beam Computed Tomography: An *In Vitro* Study

Akshay Gopa^{*}, Jyothi Kashi Nanjundasetty, Venu Gopal, John, Sharath Kumar

Department of Conservative Dentistry and Endodontics, Sri Siddhartha Dental College, Tumkur, India

***Corresponding author:** Akshay Gopal, Department of Conservative Dentistry and Endodontics, Sri Siddhartha Dental College, Tumkur, Karnataka, India. Tel: +919961252623; Email: aksgopal@gmail.com

Citation: Gopal A, Nanjundasetty JK, Gopal V, John, Kumar S (2018) Assessment of Canal Centering Ability and Canal Transportation of Protaper Universal, Protaper next and Twisted Files Using Cone Beam Computed Tomography: An *In Vitro* Study. Dent Adv Res 3: 149. DOI: 10.29011/2574-7347.100049

Received Date: 14 February, 2018; **Accepted Date:** 29 March, 2018; **Published Date:** 06 April, 2018

Abstract

Objective: To evaluate and compare the canal centering ability and canal transportation in curved root canals after instrumentation with ProTaper Universal files, Protaper Next files and Twisted Files by using CBCT.

Materials and Methods: Seventy-two human mandibular first molars were randomly divided into 3 groups (n = 24) as per the instrumentation - Group 1- ProTaper Universal, Group 2- ProTaper Next and Group 3- Twisted File. Pre & post-operative CBCT images were obtained and the shortest distance from the canal wall to the external root surface was measured in the mesio distal and bucco lingual direction at 3mm, 6mm and 9mm from apex. Statistical analysis was done using One Way ANOVA followed by post hoc Tukeys test with SPSS version 19. P value was set at < 0.05.

Results: Statistically significant difference was found between the groups with $p < 0.001$, Protaper Next showing the best performance.

Conclusion: ProTaper Next NiTi rotary system shows superior canal centering ability. There is more canal transportation towards the outer surface with ProTaper Universal and towards the inner surface with Twisted file.

Keywords: Canal Centering Ability; Canal Transportation; Protaper Next; Protaper Universal; Twisted File

Introduction

The introduction of Nickel-Titanium (Ni-Ti) rotary files in the year 1993 has made root canal preparation easier, more effective and has changed the way root canal preparations are performed these days. Most clinicians prefer Ni-Ti rotary instruments because of its several advantages over stainless steel such as its greater flexibility due to super-elasticity, the shape memory effect, a better resistance to torsional fracture and cutting efficiency, but achieving a proper taper in a curved canal is difficult as there are chances of canal transportation and loss of centering ability [1].

Deviation from the original canal curvature can lead to [2]:

1. Excessive and inappropriate dentin removal.

2. Straightening of the canal and creation of a ledge in the dentinal wall.
3. A defect known as an elbow which forms coronal to the elliptical - shaped apical seal.
4. Canal with hourglass appearance.
5. Over - preparation that weakens the tooth, resulting in fracture of the root.

There are constant modifications done by the manufactures in the file systems to achieve optimum results. Twisted Files (TF) (Axis|Sybron Endo) created by twisting the file use R-Phase heat treatment which optimizes the strength and flexibility, eliminating micro fractures [3]. The ProTaper Universal (PTU) files have increasingly larger tapers over the length of their cutting blades allowing each instrument to engage, cut and prepare a specific area of the canal [4]. The ProTaper Next (PTN) files have an offset de-

sign creating swaggering motion of the file to further minimize the engagement between the file and dentin [5,6].

There is limited data comparing the canal centering ability of ProTaper Universal, ProTaper Next and Twisted File with no consensus regarding their performance. Hence the purpose of the study was to determine and compare the canal centering ability and canal transportation of these systems in curved mesiobuccal canals of mandibular first molar using CBCT which allows three dimensional evaluations.

Materials and Methods

Seventy-two mandibular molars with curved mesial roots were selected and randomly divided into 3 groups (n= 24) as per the rotary systems, for assessment of canal centering ability and canal transportation. Group 1 - ProTaper Universal, Group 2 - ProTaper Next, Group 3 - Twisted File.

Specimen Preparation & Embedding of the Specimens in Acrylic Resin Blocks

Assess cavity preparation was done using an Endo-Access bur, and the mesiobuccal canal was localized. The distal roots with the respective part of the crown were sectioned at the furcation level and discarded. The determination of the working length was performed with dental operating microscope by inserting #10 K-Flex file to the root canal terminus subtracting 1mm from the measurement. The specimens were embedded in self-curing acrylic resin and the apices of the roots were sealed with wax and placed parallel to the long axis of the mold to ensure standardization for the tomography images before and after root canal instrumentation.

Root Canal Preparation

Instrumentation of the canal was done for each system according to the manufacturer's instructions using a power driven handpiece with an electric torque control motor (X SMART, DENTSPLY). Canals were lubricated with EDTA containing gel and irrigated with 3ml of 3.5% NaOCl solution after use of each file. At the end the canals were rinsed with 1ml of 17% EDTA solution, followed by a final NaOCl rinse.

Group 1: ProTaper Universal Rotary System. The canals were instrumented at a rotational speed of 300 rpm in the following sequence: (a) the SX file was used to half of the Working Length (WL), (b) the S1 file was used up to 4mm short of apex, (c) the S1 and S2 files were used to the full WL, and (d) the F1 and F2 files were used to the full WL.

Group 2: ProTaper Next Rotary System. The canals were instrumented at a rotational speed of 300 rpm as follows: (a) the X1 file was used to the full WL, (b) the X2 file was used to the full WL.

Group 3: Twisted File Rotary System. The canals were instru-

mented at a rotational speed of 600 rpm as follows: (a) the # 25 .08 file was up to the coronal third of the root canal, (b) the #25 .06 file was used to 4 mm short of the WL, and (c) the #25 .04 and #25 .06 files were used to full WL.

CBCT Imaging

CBCT images were obtained before and after root canal preparation. The shortest distance from the canal wall to the external root surface was measured in the bucco-lingual (X1, X*1 from buccal and X2, X*2 from lingual) and mesio-distal direction (Y1, Y*1 from mesial and Y2, Y*2 from distal) at 3mm, 6mm and 9mm from the apex. The distance was measured on the reconstructed 2-dimensional image without reduction by using the measure length tool (CS 3D software).

The calculation for canal centering ability was done accordingly:

$$D1 = (X1 - X*1) / (X2 - X*2)$$

$$D2 = (Y1 - Y*1) / (Y2 - Y*2)$$

Where D1 = Bucco lingual measurement and D2 = Mesio distal measurement.

According to this formula, a result of 1 indicates a perfect centering ability. The closer the result is to zero, the worse is the ability of the instrument to remain centered.

The calculation for canal transportation was done accordingly:

$$T1 = (X1 - X*1) - (X2 - X*2)$$

$$T2 = (Y1 - Y*1) - (Y2 - Y*2)$$

Where T1 = Buccal lingual transportation and T2 = Mesio distal transportation.

According to this formula, a result of 0 indicates no transportation. A negative value represents transportation occurring in the direction facing furcation (inner surface), whereas positive values represent transportation lateral (outer surface) to the curvature Figure 1.

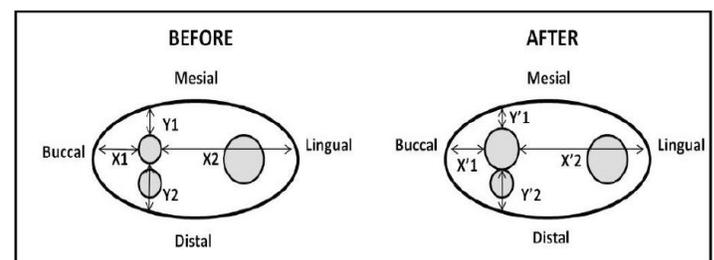


Figure 1: Schematic representation of the images used in the evaluation.

Statistical Analysis

The data was tabulated and subjected to statistical analysis

using One Way ANOVA followed by post hoc analysis using Tukeys test using SPSS (IBM, USA-Version 19.0). P value was set at < 0.05.

Results

Table 1 and 2 shows frequency and the percentage of canal transportation in various groups. Table 3, 4 and 5 shows intergroup and group wise comparison.

Groups		3mm		6mm		9mm	
		Frequency	Percent	Frequency	Percent	Frequency	Percent
Group 1	No transportation	12	50.0	14	58.3	21	87.5
	Negative	2	8.3	7	29.2	1	4.2
	Positive	10	41.7	3	12.5	2	8.3
Group 2	No transportation	21	87.5	14	58.3	19	79.2
	Negative	3	12.5	8	33.3	3	12.5
	Positive	-	-	2	8.3	2	8.3
Group 3	No transportation	5	20.8	4	16.7	21	87.5
	Negative	11	45.8	10	41.7	3	12.5
	Positive	8	33.3	10	41.7	-	-

(T1 - Bucco lingual direction)

Table 1: Frequency and percentage of canal transportation at 3mm, 6mm and 9mm from the apex.

Groups		3mm		6mm		9mm	
		Frequency	Percent	Frequency	Percent	Frequency	Percent
Group 1	No transportation	12	50.0	14	58.3	18	75.0
	Negative	3	12.5	4	16.7	4	16.7
	Positive	9	37.5	6	25.0	2	8.3
Group 2	No transportation	21	87.5	17	70.8	16	66.7
	Negative	2	8.3	5	20.8	6	25.0
	Positive	1	4.2	2	8.3	2	8.3
Group 3	No transportation	5	20.8	6	25.0	23	95.8
	Negative	8	33.3	7	29.2	1	4.2
	Positive	11	45.8	11	45.8	-	-

(T2 - Mesio distal direction)

Table 2: Frequency and percentage of canal transportation at 3mm, 6mm and 9mm from the apex.

Variables	Groups	N	Mean	SD	p value	Group wise comparison		
						1 vs 2	2 vs 3	1 vs 3
D1	1	24	.76	.27	<0.001	Sig	Sig*	-
	2	24	.94	.17				
	3	24	.64	.23				
D2	1	24	.96	.28	<0.001	Sig	Sig*	-
	2	24	.93	.19				
	3	24	.63	.23				
T1	1	24	.12	.25	.003	Sig	Sig	-
	2	24	-.01	.03				
	3	24	-.09	.27				
T2	1	24	.03	.10	.409	-	-	-
	2	24	-.01	.05				
	3	24	.02	.15				
One way ANOVA						post hoc Tukeys test *Highly significant		

Table 3: Intergroup and Group wise comparison at 3mm.

Variables	Groups	N	Mean	SD	p value	Group wise comparison		
D1	1	24	.81	.24	.034	1 vs 2	2 vs 3	1 vs 3
	2	24	.77	.28		Sig	Sig	Sig
	3	24	.63	.23				
D2	1	24	.83	.22	.011			
	2	24	.85	.23		Sig	Sig	Sig
	3	24	.66	.24				
T1	1	24	-.02	.09	.776			
	2	24	-.04	.09		-	-	-
	3	24	-.02	.14				
T2	1	24	.01	.07	.770			
	2	24	-.02	.08		-	-	-
	3	24	-.02	.24				
One way ANOVA						post hoc Tukeys test		

Table 4: Intergroup and Group wise comparison at 6mm.

Variables	Groups	N	Mean	SD	p value	Group wise comparison		
D1	1	24	.94	.17	.485	1 vs 2	2 vs 3	1 vs 3
	2	24	.90	.21		-	-	-
	3	24	.95	.13				
D2	1	24	.87	.24	.018			
	2	24	.83	.25		Sig	Sig	Sig
	3	24	.99	.05				
T1	1	24	.00	.04	.192			
	2	24	.00	.05		-	-	-
	3	24	-.02	.06				
T2	1	24	.00	.06	.830			
	2	24	-.01	.07		-	-	-
	3	24	.00	.02				
One way ANOVA						post hoc Tukeys test		

Table 5: Intergroup and Group wise comparison at 9mm.

There is statistically significant difference between the groups at 3mm for D1, D2 and T1, with p value <0.001 and 0.003 respectively. At 6mm there is difference for D1 and D2 with p value 0.034 and 0.011, whereas at 9mm there is difference only for D2 with p value 0.018.

Discussion

Mesiobuccal canals of mandibular molars usually present noticeable curvature in the apical and middle third which are susceptible to iatrogenic mishaps [7,8]. Hence the canal transportation and centering ability is evaluated at three different levels - 3mm, 6mm, and 9mm from the apex in the present study in both mesio

distal and bucco lingual direction to get a 3 dimensional understanding of the deviations using CBCT. The use of simulated root canals in resin blocks provide standardization of canal curvature allowing a high degree of reproducibility, but they do not reflect the clinical behavior of the instruments because of the different hardness of resin and dentin. Hence in the present study extracted human mandibular molars are used, to simulate the clinical scenario. The present study shows superior canal centering ability with ProTaper Next at all the levels- 3mm, 6mm, 9mm with minimum canal transportation compared to Twisted File and ProTaper Universal systems. This is similar to the study done by Dhingra et al. [9], where Protaper Next is compared with Protaper Universal.

Uzunoglu et al. [10] and Capar et al. [11] have also observed good canal centering ability with ProTaper Next and minimum canal transportation at the apical one third. Study by Liu et al. [5] and Leski et al. [1] have observed ProTaper Next removing less material from the inner aspect of the canal. This is in accordance with the present study observations.

Better performance of ProTaper Next rotary system might be due to:

1. Modified non-cutting tip design.
2. Rectangular cross section with offset design enables swagging motion, with decreased screwing effect and dangerous taper lock by minimizing the contact between the file and the dentin.
3. These instruments are used in a brushing motion, keep them away from the external root concavities, to facilitate flute unloading and apical progression [9].

There is no statistically significant difference between ProTaper Universal and Twisted File at 3mm from the apex. This is similar to the observation by Daniela et al. [3] and Andre et al. [12]. There is more canal transportation with ProTaper Universal towards the outer surface whereas with Twisted File there is more transportation to the inner surface. The more transportation with ProTaper Universal may be attributed to the greater taper (8%) and less flexibility of the instruments as explained by Schafer et al. [13], that the percentage of taper is one of the main factors involved in apical transportation. The partially active cutting tip with ProTaper Universal rotary files may be another reason for increased canal transportation. However, there is no specific reason which can be understood at this point of time with Twisted File for their decreased performance, although they have non-cutting tip, and manufactured with R-phase technology with superior flexibility imparted to the files, but Carlosael et al. [3] observed better performance of ProTaper Universal compared to Twisted File which is in contrast to the observations in the present study.

At 6mm from apex there is statically significant difference between ProTaper universal and Twisted File with more loss of canal centering ability with Twisted File. The better performance of ProTaper Universal at this level may be due to the modified cross-sectional design, decreased area of contact with the dentinal wall and U-shaped grooves which are added at each of the instruments convex triangular sides to improve flexibility and reduce transportation [3]. A study done by Maglini et al. [14] demonstrated that ProTaper Universal produces least canal transportation at the apical region and greatest at the coronal third. This may be because of the removal of dentin at the middle and coronal is more due to the increased taper of the shaping files. This is in contrast to the present study where there is less transportation at the coronal third and more in the apical third.

Many studies have shown maximum canal transportation with PTU which is attributed to progressive taper and reduced flexibility [15-18]. Wu et al. [19] has stated that the critical canal transportation value is 0.3mm, as it was found that leakage occurs more frequently when apical transportation index is $> 0.3\text{mm}$. In a similar study Peters et al. [20] reported that apical transportation $\leq 0.1\text{mm}$ is clinically acceptable. In our study an apical transportation of 0.1mm is observed with Group 1(ProTaper Universal) at 3 mm towards the outer surface which is alarming but still under clinically acceptable range. The only limitation in the present study may be the lack of the correlation of canal transportation to the amount of curvature in the root canal. This can be incorporated in the future studies where canal curvature for each specimen could be recorded (tabulated) and correlation done with the amount of canal transportation.

Conclusion

Within the limitations of the percent study the better performance was observed with ProTaper Next at all the three levels in the canal, 3mm, 6mm, and 9 mm from the apex. There is no difference in the performance of ProTaper Next and Twisted File at 3mm from apex. However, there is transportation towards the outer surface with ProTaper Next and towards the inner surface with Twisted File. At 6mm from the apex there is less transportation of the canal with ProTaper Universal compared to Twisted File. At 9mm from the apex there is not much difference between the rotary systems used in the study.

References

1. Leski M, Radwanski M, Pawlicka H (2015) Comparison of the shaping ability of Hyflex CM files with ProTaper Next in simulated L- curved canals. Dent Med Probl 52: 54-61.
2. Kandaswamy D, Venkateshbabu N, Porkodi I, Pradeep G (2009) Canal centering ability: An endodontic challenge. J Conserv Dent 12: 3-9.
3. Mendes DA, Aguiar CM, Camara AC (2011) Comparison of the centering ability of the ProTaper Universal, ProFile and Twisted File rotary systems. Braz J Oral Sci 10: 282-287.
4. Ruddle CJ (2001) The ProTaper advantages: Shaping the future of endodontics. Dentistry today, Pg No: 1-9.
5. Liu W, Wu B (2016) Root canal surface strain and canal center transportation induced by 3 different NiTi rotary instrument system. JOE 42: 299-303.
6. Ruddle CJ, Machtou P, West JD (2013) The shaping movement - Fifth generation technology. Dent Today 32: 94, 96-9.
7. Hashem AA, Ghoneim AG, Lutfy RA, Foda MY, Omar GA (2012) Geometric analysis of root canals prepared by four rotary NiTi shaping systems. J Endod 38: 996-1000.
8. Hartmann MSM, Barletta FB, Fontanella VRC, Vanni JR (2007) Canal transportation after root canal instrumentation: a comparative study with computed tomography. J Endod 33: 962-965.

9. Dhingra A, Gupta R, Singh A (2014) Comparison of Centric Ability of Protaper Next, Wave One & Protaper using Cone Beam Computed Tomography. Endodontology 26: 244-251.
10. Gogulnath D, Rajan RM, Arathy G, Kanthaswamy D (2015) A comparative evaluation of canal centering ability of three rotary nickel-titanium in the mesio-buccal canals of mandibular first molars using computed tomography. J Conserv Dent 18: 310-314.
11. Ceyhanli KT, Erdilek N, Tater I, Cetintav B (2014) comparative micro-computed tomography evaluation of apical root canal transportation with the use of ProTaper, RaCe and Safesider systems in human teeth. Aust Endod J 40: 12-16.
12. Aguiar CM, Donida FA, Camara AC, Frazao M (2013) Changes in root canal anatomy using three nickel- titanium rotary system- a cone beam computed tomography analysis. Braz J Oral Sci 12: 307-132.
13. Schafer E, Dzepina A, Danesh G (2003) Bending properties of NiTi instruments. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 96: 757-763.
14. Deepak J, Ashish M, Patil N, Kadam N, Yadav V, et al. (2015) Shaping ability of Fifth generation NiTi rotary systems for root canal preparation in curved root canals using CBCT: An *in vitro* study. J Int Oral Health 7: 57-61.
15. Stavileci M, Hoxha V, Gorduysus O, Laperre K (2013) Effects of preparation techniques on root canal shaping assessed by micro-computed tomography. Med Sci Monit Basic Res 19: 163-168.
16. Turpin YL, Chagneau F, Vulcain JM (2000) Impact of two theoretical cross-sections on torsional and bending stresses of NiTi root canal instrument models. J Endod 26: 414-417.
17. Honardar K, Assadian H, Shahab S, Jafari Z, Labbaf H (2014) Cone-beam computed tomography assessment of canal centering ability and transportation after preparation with Twisted file and BioRaCe instrumentation. Journal of Dentistry 11: 440-446.
18. Bonaccorso A, Cantatore G, Condorelli GG, Schäfer E, Tripi TR (2009) Shaping ability of four Nickel- Titanium rotary instruments in simulated S-shaped canals. J Endod 35: 883-886.
19. Wu MK, Fan B, Wesselink PR (2000) Leakage along apical root filling in curved canals. Part I effects of apical transportation on seal of root fillings. J Endod 26: 210-216.
20. Peters OA, Laib A, Gohring TN, BarBakow F (2001) changes in root canal geometry after preparation assessed by high-resolution computed tomography. J Endod 27: 1-6.