EGYPTIAN
DENTAL JOURNAL

Vol. 65, 2739:2747, July, 2019

I.S.S.N 0070-9484

Fixed Prosthodontics, Dental materials, Conservative Dentistry and Endodontics

www.eda-egypt.org • Codex : 126/1907

CONE BEAM COMPUTED TOMOGRAPHY ASSESSMENT OF CANAL TRANSPORTATION, CENTERING ABILITY, AND RADIUS CHANGE OF TWO SINGLE FILE SYSTEMS IN CURVED ROOT CANALS

Fahd M Hadhoud*

ABSTRACT

Objective: assessment the canal transportation and centering ability of two single file systems (Reciproc and Neoniti) in curved mesiobuccal (MB) root canal of natural lower first molars, by cone beam computed tomography (CBCT) scanning. **Methods:** Forty non-calcified Mesio-buccal root canals with complete formed root and apical curvature of 20-45º and Radius ≤ 15mm were chosen from extracted human lower first molars. The samples were divided based on the instrument (n=20) into two main groups **group I** (Reciproc R 25/08) and **group II** (Neoniti R 25/08). Each group has another subdivided based on the motion into (n=10) **Subgroup A**: reciprocation motion **Subgroup B**: full rotation motion. The apical transportation, centering ability and radius change were measured by pre- and post-instrumentation CBCT scans by superimposing in four section (2, 4, 6 and 8 mm from apical foramen). Values were recorded, tabulated for each group and statistically analyzed. **Results:** The ability of instruments to remain centered in prepared canals at 2and 4 mm levels was higher in Neoniti reciprocation in MD dimension. The centering ratio at 6 and 8 mm level and in BL dimension were not significantly different between the tested subgroups. The change of the radius values and percentage produced no significant difference. **Conclusion:** Both Neoniti and Reciproc systems haven`t significant difference in canal transportation, centering ability and change in curvature radius expect when using reciprocation motion Neoniti produced significantly better results than Reciproc especially in the apical third.

INTRODUCTION

Preparation of root is most important part of endodontic therapy. Preparation of curved canals has a challenge for dentists and requires a lot of training. Broken file and transportation are frequent procedural mishaps, leading to failure of treatment outcomes [1,2].

Transportation occurs due to the tendency of endodontic instruments to excessively remove dentin in a one direction within the canal equally during the preparation. It can lead to deficiency in dentin removal, ledges in the dentinal wall [3], and inadequate cleaning of the root canal, poor sealing efficiency with debris extrusion and post-treatment discomfort, which may affect the treatment prognosis [4].

* Lecturer, Endodontic Department, Faculty of Dental Medicine Assiut Branch, Al-Azhar University, Egypt

Preparation of curved canals and preserving dental anatomy at the same time are a big challenge of chosen the suitable instruments [5]. The presence of nickel-titanium (NiTi) instruments opened a new view in endodontics due to their super elasticity. Now, the idea of one file systems has been exists and is currently being used. It simplifies the preparation procedures minimal instrument failure and cross contamination.

One file systems can be distinguished according to their motion into full rotation files and reciprocating files. Neoniti A1 (NEOLIX, Chatres-la-Foret, France) is one of these newly introduced single-file systems with full rotary motion [6].

A reciprocating motion (similar to balanced force technique) [7], a shorter clockwise motion to free the file from the dentinal wall, thus allowing it to reach the apex [8].

Different methods can be used to evaluate shaping of root canal. Now, CBCT used as used. CBCT scanning provides a three-dimensional morphologic view,[9].

Comparing different systems of root canal preparation was reported less canal transport and more root canal centrality with reciprocating motion [10,11]. On other hand, some studies reveled that reciprocating action caused transportation [12,13].

MATERIALS AND METHODS

Sample Selection

Forty extracted human lower first molars that were chosen from outpatient clinic of faculty of dental medicine, Al Azhar University Assiut Branch. Roots have to be free from abnormalities as resorption, calcified canals and root fractures. The mesial root had two independent and patent mesial canals. Mesio-buccal (MB) canal curvature ranged between 20°- 45° [14] and Curvature Radius is ≤ 15mm[15].

Sample preparation

The collected teeth were soaked in 5.25% sodium hypochlorite solution for therty minutes for surface disinfection and to remove the organic debris away from the root surface. The root surface was then cleaned from any calculus debris by ultrasonic scaler and then kept moist in glass bottle containg 0.9 % normal saline (NaCl) until the time of use. Conventional access cavity was prepared, the clinical crowns were maintained and the distal roots were resected at the furcation. The working length was established by using #10 k file until it was just visible at the apical foramen and then 1mm was subtracted.

CBCT pre- instrumentation scanning procedure

The selected MB roots were impeded in silicone-based impression material until cemento-enamel junction inside plastic dental arch and scanned by I-CAT cone-beam computed tomographic device (Hatfield, PA, USA) with the following setup: 120 kVp, 38.0 mA and 0.125 voxel size and 0.13 mm axial thickness .the reconstructed 3D images were saved and measured for angle and Curvature Radius through Anatomage in vivo 5.4 software.

Sample grouping

The samples were divided depending on the instrument (n=20) into two main groups group I (Reciproc R 25/08; VDW, Munich, Germany), and group II (Neoniti R 25/08; 11 av. Raoul Vadepied – FR-53600 Chatres-la-Foret ,France). Each group was subdivided based on the motion into Subgroup A: reciprocation motion (RM) (n=10), and Subgroup B: full rotation motion (CM) (n=10).

Root Canal Instrumentation

Firstly a glide path was created by scouting size #15 K-file hand file up to WL. Then, Ni Ti rotary systems were used, the endo motor for subgroups IA, and IIA: was adjusted on preset speed and torque programs ("Reciproc All"). Subgroup IB: the endo motor was set on reverse action to generate effective continuous rotation at 3 Ncm torque and

350 rpm [16]. Subgroup IIB: the same motor was set at a constant speed of 400 rpm and torque of 1.5Ncm in continuous clockwise rotation. Each rotary instrument was used in a slow in-and-out pecking motion and using an EDTA-containing gel as a lubricant. After 3 pecks, the instrument was removed and cleaned off. The canal was irrigated with 2.5% NaOCl solution using 27-G NaviTip needle that was inserted as deep as possible into the canal without binding. The ISO size #10 k file was introduced to the full working length to recheck patency. Files were discarded after preparation of four canals.

CBCT post-instrumentation images Scanning

After instrumentation the teeth in the same dental arch position were scanned for reconstruction of the post instrumentation images with the same protocol and parameter settings. The reconstructed axial-sectional images of the pre and post instrumentation scans were superimposed. Dentine thickness of the pre and post instrumentation images at 2, 4, 6, and 8 mm axial sectional levels from the apex were measured independently in buccolingual and mesiodistal dimensions by using of Anatomage invivo 5.4 software.

Evaluation of root canal transportation and centering ability

Transportation was calculated at each level by following equation:

$(m1- m2) - (d1- d2)$ and $(l1- l2) - (b1- b2)$

Centering ability was calculated by the formula: $(m1- m2) / (d1- d2)$ or $(d1- d2) / (m1- m2)$ and $(b1- b2) / (l1- l2)$ or $(l1- l2) / (b1- b2)$

Radius of curvature changes was measured by: Rad2 – Rad1 [17] (Figure 1,2).

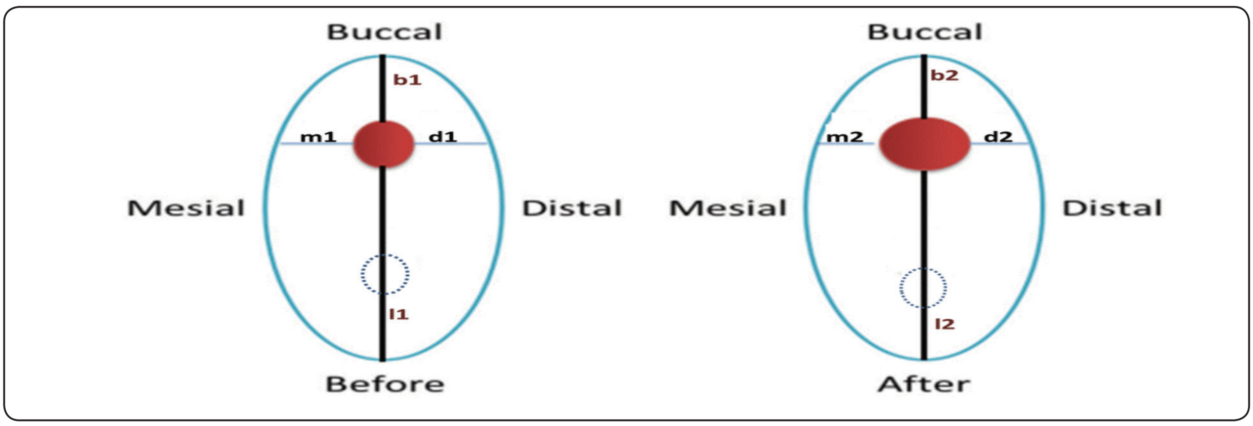

Fig. (1) Illustration diagram showing the remaining dentin thickness before and after instrumentation.

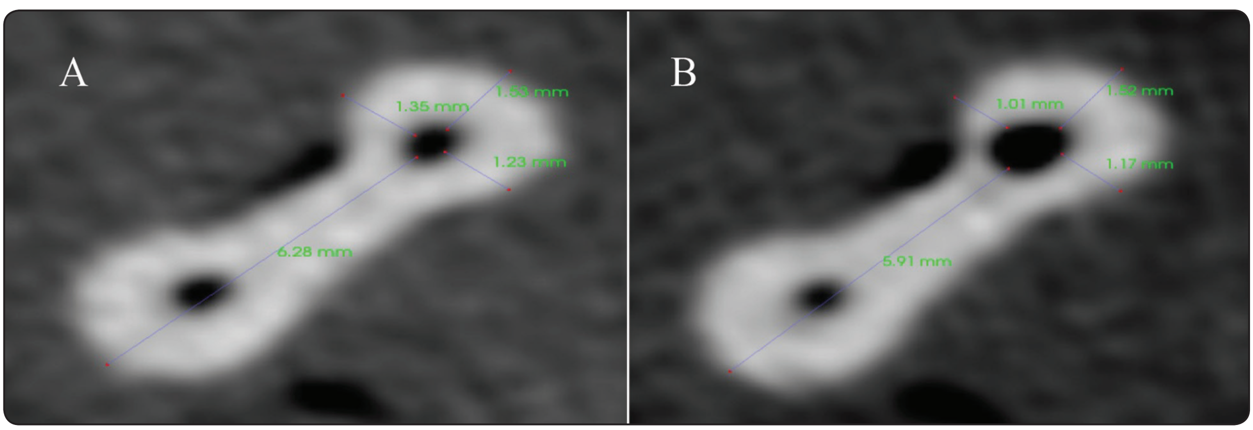

Fig. (2) CBCT images at 8-mm distance from the apex; A) pre- and B) post-instrumentation images with Reciproc CM. Amount of canal transportation was obtained from (m1-m2)-(d1-d2) formula.

RESULTS

A. Amount of canal transportation

The mean ± SD for mesiodistal and buccolingual transportation values in both systems using Mann-Whitney U test are shown in Table 1. Either in comparison between motions within the same file or between the two file system in rotation, reciprocation and manufacture motion, There was no statistically significant difference in canal transportation among the subgroups at three studied levels (2, 4, and 8 mm from the root apex) (p>0.05) in both BL and MD directions, but at 6mm level where the mean±SD Neoniti CM 0.24±0.12 produced significantly more amount of canal transportation than Neoniti RM in MD direction. Moreover it resulted in more transportation than Reciproc RM and CM in MD direction but less than Reciproc CM in BL direction but with no statistically significant difference (Figure 3).

TABLE (1) Transportation in mm at the defined levels (MD=mesio-distal, BL=bucco-lingual).

System	Root level	MD transportation		P-value	BL transportation		P-value
		Rotation	Reciprocation		Rotation	Reciprocation	
		Mean(SD)	Mean(SD)		Mean(SD)	Mean(SD)	
Reciproc	2 mm	0.11(0.10)	0.13(0.10)	>0.05	0.10(0.06)	0.11(0.09)	>0.05
	4 mm	0.09(0.08)	0.16(0.12)	>0.05	0.08(0.06)	0.12(0.06)	>0.05
	6 mm	0.19(0.09)	0.12(0.09)	>0.05	0.21(0.12)	0.12(0.09)	>0.05
	8 mm	0.14(0.10)	0.18(0.06)	>0.05	0.23(0.11)	0.23(0.14)	>0.05
	Total	0.07(0.04)	0.05(0.04)	>0.05	0.11(0.07)	0.10(0.06)	>0.05
Neoniti	2 mm	0.07(0.04)	0.07(0.06)	>0.05	0.06(0.03)	0.05(0.03)	>0.05
	4 mm	0.12(0.09)	0.07(0.07)	>0.05	0.09(0.10)	0.09(0.08)	>0.05
	6 mm	0.24(0.12)	0.10(0.08)	<0.05*	0.17(0.12)	0.09(0.07)	>0.05
	8 mm	0.14(0.06)	0.13(0.06)	>0.05	0.21(0.13)	0.14(0.11)	>0.05
	Total	0.08(0.06)	0.07(0.06)	>0.05	0.09(0.05)	0.06(0.03)	>0.05

: Significant at $P \leq 0.05$

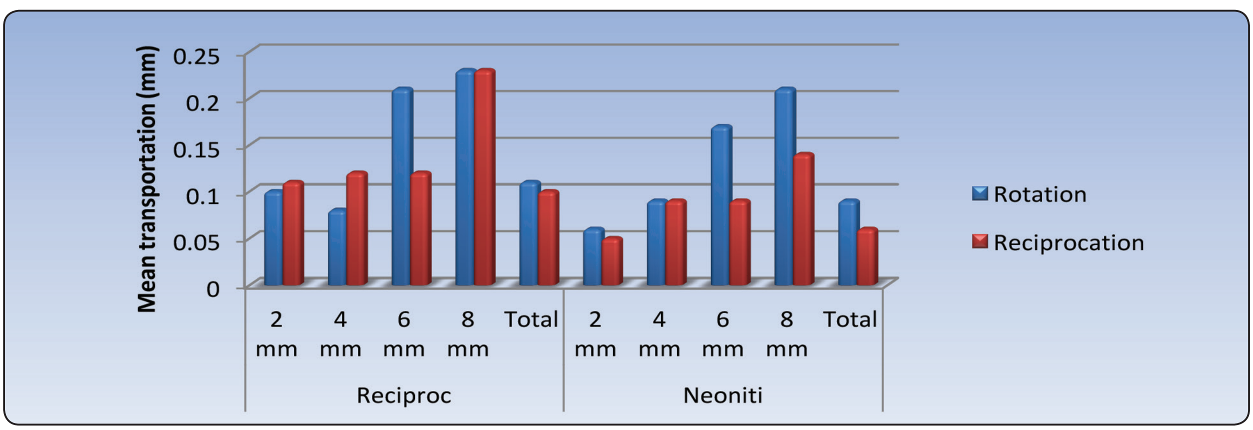

Fig. (3): Histogram showing the rate of transportation.

B. Centering ability

The mean ±SD for mesio-distal and bucco-lingual centering ratio values in both systems using Mann-Whitney U test are shown in Table 2. Either in comparison between motions within the same file or between the two file system in rotation ,reciprocation and manufacture motion, The ability of instruments to remain centered in prepared canals at 2and 4 mm levels was significantly higher in Neoniti RM ($p < 0.05$) than Reciproc (RM) and Neoniti(CM) in MD dimension. However the centering ratio at 6 and 8 mm and at each section of the root canal in BL dimension were not significantly different among the tested subgroups(p>0.05) (Figure 4).

TABLE (2): Centering ratio in mm at the defined levels (MD=mesio-distal, BL=bucco-lingual).

System	Root level	MD centering ratio		P-value	BL centering ratio		P-value
		Rotation	Reciprocation		Rotation	Reciprocation	
		Mean(SD)	Mean(SD)		Mean(SD)	Mean(SD)	
Reciproc	2 mm	0.50(0.31)	0.49(0.28)	0.915	0.45(0.24)	0.56(0.23)	0.762
	4 mm	0.58(0.24)	0.41(0.20)	0.739	0.64(0.17)	0.50(0.38)	0.128
	6 mm	0.38(0.17)	0.56(0.32)	0.055	0.44(0.20)	0.47(0.21)	0.847
	8 mm	0.45(0.29)	0.39(0.19)	0.722	0.34(0.19)	0.43(0.32)	0.693
	Total	0.48(0.13)	0.46(0.10)	0.858	0.47(0.11)	0.49(0.12)	0.684
Neoniti	2 mm	0.48(0.25)	0.65(0.22)	0.040*	0.52(0.31)	0.54(0.32)	0.928
	4 mm	0.45(0.27)	0.63(0.25)	0.038*	0.45(0.23)	0.51(0.34)	0.759
	6 mm	0.38(0.27)	0.51(0.22)	0.078	0.43(0.28)	0.48(0.22)	0.615
	8 mm	0.40(0.23)	0.50(0.27)	0.686	0.41(0.24)	0.44(0.36)	0.802
	Total	0.43(0.15)	0.57(0.18)	0.066	0.45(0.15)	0.49(0.14)	0.631

: Significant at $P \leq 0.05$

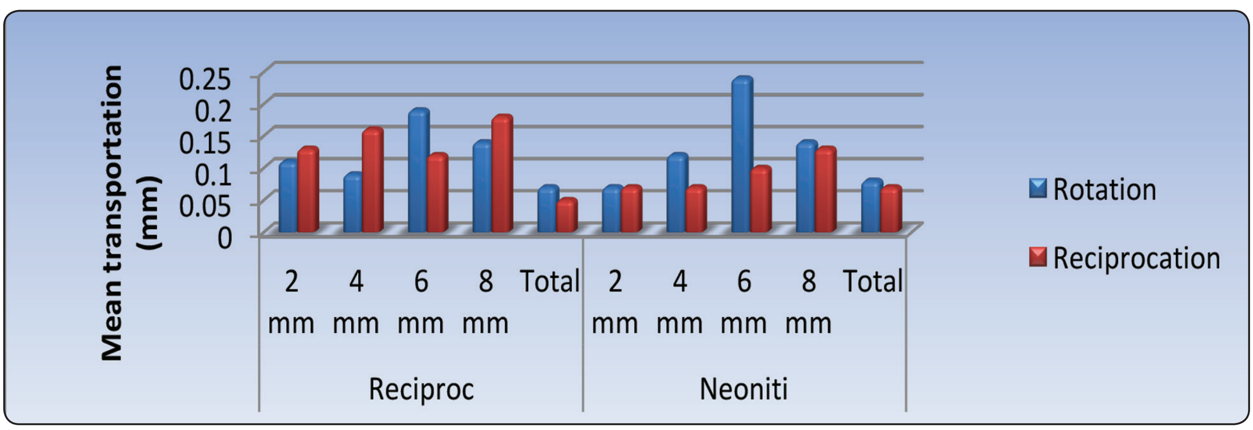

Fig. (4) Histogram showing the rate of centering ratio.

C- Radius change:

The mean ± SD for the radius of curvature of two groups using Mann-Whitney U test are shown in Table 3.The data for the change of the radius values and percentage produced no statistically significant difference between all subgroups (p>0.05).

TABLE (3) Radius curvature of root canals.

	Motion	Reciproc	Neoniti	P-value
		Mean(SD)	Mean(SD)	
Change (°)	Rotation	3.76 (2.12)	2.86 (1.44)	>0.05
	Reciprocation	3.50(2.67)	2.38(1.51)	>0.05
% Change	Rotation	30.82(18.14)	23.55(11.64)	>0.05
	Reciprocation	28.10 (22.52)	20.88 (15.52)	>0.05

: Significant at P ≤ 0.05

DISCUSSION

The purpose of root canal preparation is the optimum cleaning and shaping of root canal system while maintaining the original curvature of the canal and without creating any procedural error such as instrument fracture, blockage, perforation, zipping and apical canal transportation. NiTi instruments have been developed in attempts to overcome the short coming imposed by stainless steel alloy. Their super elasticity and shape memory effect tend the files to negotiate curved canal better and reduce the procedure errors [18].

The concept of using single file system is a new perspective for NiTi rotary file usage technique and is gaining clinical acceptance as they reduce the time required for biomechanical preparation and reduce the number of failure related to instrumentation as well as the cost saving compared to rotary system with multiple instruments[19].

One of the most popular reciprocating system used nowadays is the Reciproc, where the system consist of single file for full length canal preparation with advantage of using new metallurgy of M wire that offers greater flexibility and greater resistance to cyclic fatigue and less incidence to fracture its cutting design and its motion allow it to go through the canal in less preparation time compared to traditional rotary techniques in continuous motion with maintaining the canal shape [20].

Neolix file is an innovative single file continuous rotation system mode of CM wire with electric discharge machining .this produces a file with especially hard and naturally rough surface that allows the file to be more flexible with higher resistance to fatigue and possibility of pre-curving in difficult canal access as claimed by manufacture[21].

When comparing the cleaning abilities of different preparation techniques or different root canal instruments, it is of importance to have similar apical preparation diameter [22]. Reciproc R25 (0.25-mm diameter and 0.08 taper in the first 3 mm), and Neoniti (0.25-mm diameter and 0.08 taper in the first 5 mm) were selected.

The mesio- buccal canals of the extracted human mandibular molars were selected, as it offers the advantage of three dimension nature of the root canal curvature. Not only this, but also the hardness of the dentine and irregularities of the root canal system in the extracted teeth is closer to the in vivo situation than with the use of the plastic blocks with the simulated root canals in which it not produce the natural dentin removal behavior and during its instrumentation heat generation soften the resin and effect on the results [23].The Schneider's method was used in combination with the radius of the curve as it is considered by far the more exact method of describing the canal curvature [24].

Although several methodologies may be used to analyze instrumentation effect on root canal, a reliable methods is necessary in order to verify the root canals before and after instrumentation .The use of CBCT provide non-aggressive 3D information from the preoperative and postoperative images of the cross-section of root canal at different levels that can also be easily superimposed in 3D facilitates the evaluation of the significant parameters of root canal preparation [25].

The idea to compare both file systems under the same motion (rotation, reciprocation and original manufacture motion) to investigate the effect of alloy and geometry on shaping ability of the canal was done for the first time.

This study investigated amount centering ability, canal transportation, and radius change induced by two engine-driven single-file systems, Reciproc and Neoniti of curved mesio-buccal (MB) root canal of extracted human lower first molars using CBCT. It was found that Either in comparison between both fill rotation and reciprocation motions within the same file or between the two file system in full rotation ,reciprocation and manufacture motion, There was no statistically significant difference in canal transportation among the subgroups at three studied levels (2, 4, and 8 mm from the root apex) ($p>0.05$) in both BL and MD directions, except at 6mm level where Neoniti CM produced significantly more amount of canal transportation than Neoniti RM in MD direction.

Neoniti (CM) at 6 mm significantly remove the highest amount of dentine from the distal wall (danger zone) of the canal , It may be attributed to Neoniti C1; (taper 0.12) did not used for coronal pre-flaring[26]. Resulting in more friction that worsened with continuous engagement of dentine during continuous rotation motion of Neoniti with more incidence of apical transportation [18].

A study reported that Cross section of Neoniti is a homothetic rectangle, may have led to aggressive cutting and caused canal transportation [27].

Where only Neoniti A1 file (taper 0.8) was used as single file (according to purpose of the study) because the simplified instrument design has enabled "single-length technique" which is adopted by ProTaper, OneShape and Neoniti instruments. The order used files are introduced into the canal at the full working length to prepare the whole canal [20,21] Another reason must be considered that cervical preparation can influence the outcome of canal shaping [28]. Vallabhaneni et al. reported that At 7 mm level, bucco-lingually, there was statistically significant transportation with Neoniti than WaveOne Gold among 3,5,7mm. He explained it by the coronal pre-flaring with Neoniti C1, (taper 0.12) used in circumferential brushing motion [26].

Chapela et al. used a CBCT scanner and found that there was no significant difference between continuous rotation and alternating rotation in canal transportation or the centering ratio at at 3, 5, and 7 mm from the apex [29].

With regard to centering ability

Either in comparison between full rotation and reciprocation motion within the same file or between the two file systems in full rotation, reciprocation and manufacture motion, none of the instruments tested in the present study remained perfectly centralized within the root canal.

Moreover, no differences were observed among the subgroups, **Stern *et al.*** evaluated the centering and the shaping ability of ProTaper® used in reciprocating motion and in continuous rotary motion observing no differences between the techniques, corroborating with their results [30]. This finding comes in agreement with Članak IZ (F360®, F6-SkyTaper®, Hyflex-EDM®, iRACE®, Neoniti®, O.Shape®, P.Next®, Reciproc®, Revo-S® and Wave-One-Gold®) and concluded that Regarding the root canal anatomy preservation, all 10 file systems were similar[31].

The findings of this experimental study are not consistent with the study of Moazzami et al. compared root canal transportation by Neoniti and Reciproc using cone-beam computed tomography (CBCT) and stated that Neoniti and Reciproc systems have significant difference in terms of creating canal transportation. Reciproc created more canal transportation in bucco-lingual and mesio-distal dimensions [32].

However ,the ability of instruments to remain centered in prepared canals at 2and 4 mm levels was observed significantly higher in Neoniti RM ($p < 0.05$) than Reciproc (RM) and Neoniti(CM) in MD dimension. However the centering ratio at 6 and 8 mm were not significantly different. . Reciprocating movements reduce the screw-in effect due to clockwise rotation may relieve the stress when the instrument is trapped in dentin during counterclockwise rotations allow smooth transition of the file across the whole length of canal with less iatrogenic errors [33].

Reciproc has a sharp double-cutting edge and S-shaped geometry while Neoniti files have non-homothetic rectangular cross sections with rounded Gothic tips[34]. Furthermore, Neolix files do not show the usual metallic memory. The manufacturer has claimed that this special feature is due to the use of a newly developed wire-cut electrical discharge machining (WEDM) process and an appropriate heat treatment in manufacturing of these files [32].

There was no difference between the mean value and standard deviation of changes as well as % changes in canal curvature angle with the two systems .This finding comes in agreement with **Madani** who reported that there were no significant differences between the groups in terms of the change in canal angle ($P > 0.05$). The Neolix system produced less canal deviation at 7 of the 12 measuring points ($P<0.05$) [35].

CONCLUSION

Neoniti and Reciproc systems have no significantly difference in creating canal transportation, centering ability and change in radius curvature expect when using reciprocation motion Neoniti produced significantly better results than Reciproc especially in the apical part of curved canals.

REFERENCE

1. Peters OA. Current challenges and concepts in the preparation of root canal systems: a review. J Endod. 2004; 30(8):559–67.
2. Koch M, Tegelberg A, Eckerlund I, Axelsson S. A cost-minimization analysis of root canal treatment before and after education in nickel-titanium rotary technique in general practice. Int Endod J. 2012; 45(7):633–41.
3. Yamamura B, Cox TC, Heddaya B, Flake NM, Johnson JD, Paranjpe A. Comparing canal transportation and centering ability of endosequence and vortex rotary files by using micro-computed tomography. J Endod. 2012; 38:1121–5.
4. Pak JG, White SN. Pain prevalence and severity before, during, and after root canal treatment: A systematic review. J Endod. 2011; 37:429–38.
5. Viana AC, Chaves Craveiro de Melo M, Guiomar de Azevedo Bahia M, Lopes Buono VT. Relationship between flexibility and physical, chemical, and geometric characteristics of rotary nickel-titanium instruments. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010; 110:527–33.
6. Dhingra A, Gupta R, Yadav V, Aggarwal N. Endodontic retreatment using single file neoniti system. American J Oral Mede and Radiol. 2015; 2(4):206-8.
7. Coelho M , CarloFontana C. Effects of Glide Path on the Centering Ability and Preparation Time of Two Reciprocating Instruments. Iran Endod J. 2016; 11(1): 33–37.
8. Berutti E, Paolino DS, Chiandussi G, Alovisi M, Cantatore G, Castellucci A. Root canal anatomy preservation of WaveOne reciprocating files with or without glide path. J Endod. 2012; 38(1):101–4.
9. Hartmann MS, Barletta FB, Camargo-Fontanella VR, Vanni JR. Canal transportation after root canal instrumentation: A comparative study with computed tomography. J Endod. 2007; 33:962–5.
10. De Deus G, Moreira E, Lopes H, Elias C. Extended cyclic fatigue life of F2 ProTaper instruments used in reciprocating movement. Int Endod J. 2010;43(12):1063-8.
11. Varela-Patino P, Martin-Biedma B, Rodriguez-Nogueira J, Cantatore G, Malentaca A, Ruiz-Pinon M. Fracture rate of nickel-titanium instruments using continuous versus alternating rotation. Endodontic Practice Today. 2008; 2(3).
12. Gergi R, Arbab-Chirani R, Osta N, Naaman A. Micro–Computed Tomographic Evaluation of Canal Transportation Instrumented by Different Kinematics Rotary Nickel-Titanium Instruments. J Endod. 2014; 40(8):1223-7.

13. Nabavizadeh M, Abbaszadegan A, Khojastepour L, Amirhosseini M, Kiani E. A comparison of apical transportation in severely curved canals induced by reciproc and BioRaCe systems. Iran Endod J. 2014;9(2):117.

14. Schneider SW.A comparison of canal preparations in straight and curved root canalsOral Surg Oral Med Oral Pathol.1971; 32 (2): 271-5.

15. Estrela C, Bueno MR , Sousa-Neto MD and Pécor JD. Method for Determination of Root Curvature Radius Using Cone-Beam Computed Tomography Images. Braz Dent J .2008; 19(2): 114-8.

16. Naseri M, Paymanpour P, Kangarloo A, Haddadpur S, Dianat O, and Ketabi MA. Influence of motion pattern on apical transportation and centering ability of WaveOne single-file technique in curved root canals. Dent Res J. 2016; 13(1): 13–7.

17. Short JA, Morgan LA, Baumgartner JC. A comparison of canal centering ability of four instrumentation techniques. J Endod. 1997; 23(8):503-7.

18. Song YL,BianZ, Fan B, GutmanJL, PengB. Acomparison of instrument centering ability within the root canal for three contemporary intrumentition techniques. Int Endod J. 2004; 37(4):265-71.

19. Moura-netto C , Palo RM, Pinto LF , Mello-moura ACV, Daltoé G, Wilhelmsen NSW.CT study of the performance of reciprocating and oscillatory motions in flattened root canal areas. Braz Oral Res. 2015; 29(1):1-6.

20. Madani ZS, Haddadi A, Haghanifar S, Bijani A. Cone-beam computed tomography for evaluation of apical transportation in root canals prepared by two rotary systems. Iran Endod J. 2014; 9 (2):109–12.

21. Ehsani M, Zahedpasha S, Moghadamnia AA, Mirjani J. An ex-vivo study on the shaping parameters of two nickel-titanium rotary systems compared with hand instruments. Iran Endod J. 2011; 6(2):74–9.

22. Netto CM , Palo b RM , Pinto LF, Volpi mello-moura AC , Daltoé G .Study of the performance of reciprocating and oscillatory motions in flattened root canal areas. Braz. oral res. 2015; 29 (1):1-7.

23. Peterson TB, McClanahan S. Comparisons of the Shaping Abilities of Three NiTi File Systems Using Rotational versus Reciprocal Movements .University Digital Conservancy, Master's Theses . 2014:61.

24. Balani P, Niazi1F, Rashid H. A brief review of the methods used to determine the curvature of root Canals. J Rest Dent.2015; 3 (3):57-63.

25. NurB G, Ok E, Altunsoy M, Aglarci OS, Colak M, Gungor E. Evaluation of the root and canal morphology of mandibular permanent molars in a south-eastern Turkish population using cone-beam computed tomography. Eur J Dent. 2014; 8(2):154–59.

26. Vallabhaneni S, Fatima K, Kumar TH. Cone-beam computed tomography assessment of root canal transportation using WaveOne Gold and Neoniti single-file systems. J conserve dent. 2017; 20(6): 434-8.

27. Forghani M, Hezarjaribi M, Teimouri H. Comparison of the shaping characteristics of Neolix and Protaper Universal systems in preparation of severely-curved simulated canals. J Clin Exp Dent 2017; 9:556-9.

28. Al-Sudani D1, Kaabi H2, Al Gamdi A3, Al Dakheel A4. The influence of different angles and reciprocation on the shaping ability of two nickel-titanium rotary root canal instruments. J Contemp Dent Pract. 2014; 15(4):451-5.

29. González-Chapela J, Castelo-Baz P, Varela-Patiño P, Martín-Biedma B, Ruíz-Piñón M. Alternating versus continuous rotation: Root canal transportation and centering ratio with the ProTaper Next. J Conserv Dent. 2017; 20(4):255-9.

30. Stern S, Patel S, Foschi F, Sherriff M, Mannocci F. Changes in centring and shaping ability using three nickel–titanium instrumentation techniques analyzed by micro-computed tomography (μCT). Int Endod J. 2012; 45:514-23.

31. Endodonciju ZZ, Valencija KS, članak IZ .**Comp**arison of Shaping Ability of 10 Rotary and Reciprocating Systems. Acta stomato Croatica. 2017; 51 (3):207-16.

32. Moazzami F, Khojastepour,L Nabavizadeh M, and Habash MS. Cone-Beam Computed Tomography Assessment of Root Canal Transportation by Neoniti and Reciproc Single-File Systems. Iran Endod J. 2016; 11(2): 96–100.

33. Ha JH, Kwak SW, Kim HC. Screw-in forces during instrumentation by various file systems. Rest Dent Endod. 2016; 41(4): 304–9.

34. Gupta R DA, Aggarwal N, Yadav V. A new approach to single file endodontics: Neoniti rotary file system. Int J Advances In Case Reports. 2015; 2(16):1030-2.

35. Madani Z, Soleymani A, Bagheri T, Moudi E, Bijani A, and Rakhshan V. Transportation and centering ability of neoniti and protaper instruments; A CBCT Assessment. Iran Endod J. 2017; 12(1): 43–9.