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Influence of Motion Pattern on Shaping Ability of Two Single File Systems in Curved Root Canals

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ABSTRACT

Purpose: This study was conducted to compare and evaluate the influence of motion pattern on shaping ability of two single file systems (Reciproc and Neoniti) in severely curved mesiobuccal (MB) root canal of human mandibular first molars using cone beam computed tomography (CBCT) scanning. **Materials and Methods:** Forty non-calcified Mesio-buccal root canals with mature apices and apical curvature of 20-45^o and Radius less than 15mm were selected from extracted human mandibular first molars. The samples were divided according to the instrument (n=20) into group I (Reciproc R 25/08) and group II (Neoniti R 25/08). Each group was subdivided according to the motion (n=10) Subgroup A: reciprocation motion (RM) Subgroup B: full rotation motion (CM). After preparation, the amount of apical transportation, centering ability and radius change were assessed by evaluating pre- and post-instrumentation CBCT scans by superimposing in four section (2, 4, 6 and 8 mm from apical foramen). the significance level was set at $P \leq 0.05$. **Results:** There was no ststistical 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 Bucco-Lingual and Mesio-Distal directions, but at 6mm level where Neoniti CM peroduced significantly more amount of canal transportation than Neoniti RM in MD direction. The ability of instruments to remain centered in prepared canals at 2 and 4 mm levels was significantly higher in Neoniti RM ($P<0.05$) in MD dimension. The centering ratio at 6 and 8 mm level and in BL dimension were not significantly different among the tested subgroups(P>0.05). The change of the radius values and percentage produced no statistically significant difference. **Conclusion:** The motion pattern has an impact on the shaping ability of the severely curved root canal. Reciprocation motion enhances transition of the file inside the canal with minimal procedural errors.It seems that the difference between Neoniti and Reciproc is of little importance concerning apical transportation and centering ability and Radius change. Also both files preserve the root canal anatomy.

KEYWORDS

Full; rotation; Reciprocation; Single-file; Canal transportation; Centering ability; Cone beam computed tomography (CBCT) scanning

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INTRODUCTION

The shaping is one of the most important steps of endodontic therapy. File separation and transportation are frequent procedural mishaps[1]. Transportation occurs due to the tendency of endodontic instruments to excessively remove dentin in a single direction within the canal rather than in all directions equidistantly during the chemo-mechanical preparation, which may adversely affect the prognosis of the treatment[2]. The need to enlarge curved canals and at the same time preserve dental anatomy will always involve the challenge of selecting appropriate endodontic instruments [3]. The introduction of nickel-titanium (NiTi) instruments opened up new perspectives in Endodontics due to their superelasticity. Recently, the concept of single-file systems is being debated for its applicability in contemporary endodontics. It simplifies the instrumentation protocol while reducing the risk of instrument failure and cross contamination. Single-file rotary systems may be classified on the basis of their motion into rotating and reciprocating files [4, 5].

Neoniti A1 (NEOLIX, Chatres-la-Foret, France) is one of these newly introduced single-file systems with full rotary motion. This system has continuous rotating movement and is made up of special alloy that permits the file flexibility. This system is produced with three different sizes (20/0.08, 25/0.08 and 40/0.08) that are recommended to be used with speed of 300 to 500 rpm and torque limit of 1.5 N/cm. According to the manufacturer this file offers many advantages such as sharp cutting edges, single-file technique, Gothic-like tip design and built-in abrasive properties [6].

A reciprocating back and forth motion (similar to balanced force technique) [7]. It produces a counterclockwise motion that allows the instrument engagement with dentin, and a shorter clockwise motion to release the file from the dentin wall, thus allowing it to advance towards the apex [8]. Several studies have reported that reciprocating motion decreased the impact of cyclic fatigue, minimized torsional and flexural stresses [9]. Reciproc (VDW, Munich, Germany) has S-shaped cross section, a non-cutting tip and sharp cutting edges that shape the canal by means of a reciprocal back-and-forward motion (150 degrees counterclockwise and then 30 degrees clockwise). This single file-system is available at three different sizes and tapers; R25 (25/0.08), R40 (40/0.06) and R50 (50/0.05) [10] .Previous studies using this system in extracted teeth have shown that it can maintain the original shape of root canal similar to conventional rotary systems [11].

Different methods can be used to evaluate shaping of root canal. Recently, CBCT is used as a noninvasive method to measure apical transportation and centering ability and also provides a three-dimensional morphologic view, which is considered superior to conventional radiographs and digital radiographic techniques [12, 13].Previous studies that have compared systems of root canal shaping with continuous rotation and reciprocating motion, reported less canal transport and more root canal centrality with reciprocating motion [5,14]. On the contrary, some studies stated that reciprocating movement caused more transportation [15, 16]. So still there is limited information regarding the influence of reciprocating motion on canal transportation compared to continuous rotation. Therefore, this study was conducted to compare and evaluate the influence of motion pattern on Shaping ability of two single file systems (Reciproc and Neoniti) in severely curved mesiobuccal (MB) root canal of human mandibular first molars, using cone beam computed tomography (CBCT) scanning .

MATERIALS AND METHOD

Samples selection:

A total of forty extracted human mandibular first molars that were collected from outpatient clinic of Faculty of Dental Medicine (for girls), Al Azhar

University. Ethical approval for the use of extracted human teeth was obtained in accordance with Guidelines from research ethics committee approval of Dental Medicine Faculty -Al-Azhar University for girls. 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^{o}-45^{o} according to Schneider's technique[17] and Radius of curvature is ≤ 15mm based on Estrela method [18] .

Samples preparation

The collected teeth were immersed 5.25% sodium hypochlorite solution for 30 minutes at room temperature for surface disinfection and to remove the organic debris and then kept moist in 0.9% normal saline until the time of use. Conventional access cavity was prepared with maintaing the whole crown while 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 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 radius of curvature through Anatomage in vivo 5.4 software.

Samples grouping:

The samples were divided according to the instrument (n=20) into group I (Reciproc R 25/08) and group II (Neoniti A 25/08). Each group was subdivided according to the motion (n=10) Subgroup A: reciprocation motion (RM) and Subgroup B: continuous rotation motion (CM).

Root canal Instrumentation

Firstly a glide path was created by scouting size #15 c piolet hand file up to WL. Then, Ni Ti rotary systems were used, the endo motor for subgroups IA, and IIA: was adjusted on preset ("Reciproc All"). Subgroup IB: the endo motor was set on reverse action to generate effective continuous rotation at 3 Ncm torque and 350 rpm [5]. Subgroup IIB: the same motor was set at 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 . 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 images of the pre and post instrumentation scans were superimposed in sagittal view. axial cross sections of the pre and post instrumentation images were made independently at 2, 4, 6, and 8 mm from the apex using Anatomage invivo software Dentine thickness of axial cross sections of the pre and post instrumentation images at 2, 4, 6, and 8 mm from the apex were measured in buccolingual and mesiodistal dimensions using of Anatomage invivo 5.4 software tools.

Evaluation of root canal transportation and centering ability

Transportation was calculated at each level by following equation:

$$(m1- m2) - (d1- d2) \text{ and } (L1- L2) - (b1- b2)$$

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

Where m1 is the shortest distance between mesial (or L1 lingual) aspect of non instrumented canal to mesial (or lingual) edge of the root, and m2 is the shortest distance between mesial (or L2 lingual) aspect of instrumented canal to the mesial (or lingual) edge of the root. Likewise d1 is the shortest distance between distal (or b1 buccal) aspect of non-instrumented canal to distal (or buccal) edge of the root, and d2 is the shortest distance between distal (or b2 buccal) aspect of instrumented canal to distal (or buccal) edge of the root [19]. The result 0 indicates no canal transportation, negative results means distal (or buccal) transportation and positive results show mesial (or lingual) transportation (Figure 1).

Statistical Analysis

Statistical analysis was performed with Mann-Whitney U test, paired t-test and Fisher's exact test, the significance level was set at P ≤ 0.05. Data were presented as mean, median, standard deviation (SD), minimum, maximum and 95% Confidence Interval (95% CI) for the mean values. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows

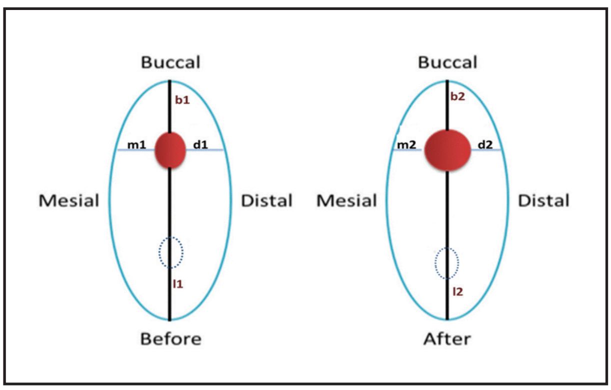

Fig. (1) Illustration diagram showing the remaining dentin thickness before and after instrumentation.

RESULTS

A) Amount of canal transportation

The mean and standard deviation 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 manufacturer motion, There was no statistical 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, however at 6mm level Neoniti CM peroduced significantly more amount of canal transportation than Neoniti RM in MD direction with significant deviation toward the distal wall (danger zone) . (Figure 2, 3).

B) Centering ability

The mean and standard deviation for mesiodistal and buccolingual 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 manufacuture 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).

C) Radius change:

The mean and standard deviation 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 1. *Mean and (SD) of the transportation in mm at the defined levels (MD=mesiodistal, BL=buccolingual)*

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)	0.529	0.10(0.06)	0.11(0.09)	0.165
	4 mm	0.09(0.08)	0.16(0.12)	0.190	0.08(0.06)	0.12(0.06)	0.684
	6 mm	0.19(0.09)	0.12(0.09)	0.105	0.21(0.12)	0.12(0.09)	0.481
	8 mm	0.14(0.10)	0.18(0.06)	0.280	0.23(0.11)	0.23(0.14)	0.631
	Total	0.07(0.04)	0.05(0.04)	0.436	0.11(0.07)	0.10(0.06)	0.529
Neoniti	2 mm	0.07(0.04)	0.07(0.06)	0.631	0.06(0.03)	0.05(0.03)	0.393
	4 mm	0.12(0.09)	0.07(0.07)	0.218	0.09(0.10)	0.09(0.08)	0.218
	6 mm	0.24(0.12)	0.10(0.08)	0.009*	0.17(0.12)	0.09(0.07)	0.481
	8 mm	0.14(0.06)	0.13(0.06)	0.579	0.21(0.13)	0.14(0.11)	0.143
	Total	0.08(0.06)	0.07(0.06)	0.684	0.09(0.05)	0.06(0.03)	0.247

**: Significant at $P \leq 0.05$*

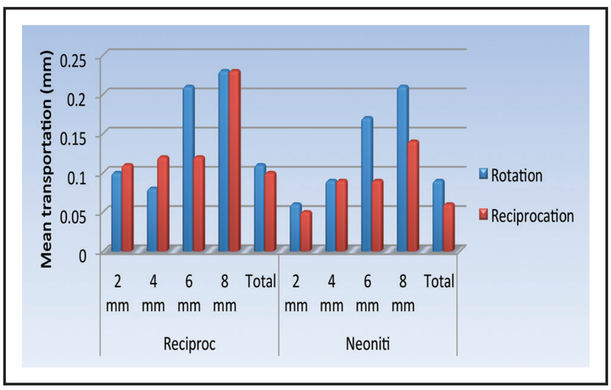

Fig. (2) Bar chart comparing Transportation at 2, 4, 6 and8 mm from the apex of Neoniti and Reciproc system.

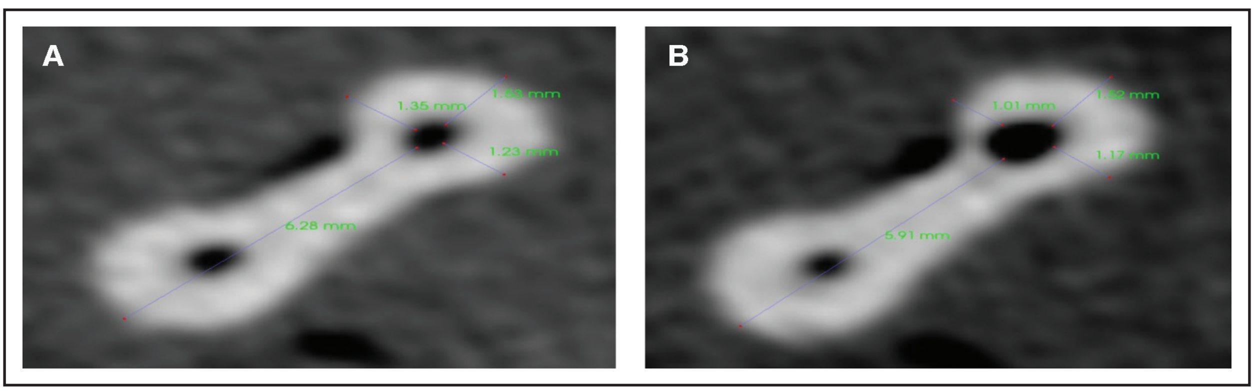

Fig. (3) CBCT , A) pre- and B) post-instrumentation images of a sample prepared with Neoniti CM at 6-mm distance from the apex.

Table (2): *Mean (SD) of centering ratio in mm at the defined levels (MD=mesiodistal, BL=buccolingual)*

System	Root level	MD centering ratio		*P*-value	BL centering ratio		*P*-value
		Rotation	Reciproc-ation		Rotation	Reciproc-ation	
		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 ≤ 0.05*

Table 3. *Mean (SD) of radius curvature of root canals*

	Motion	Reciproc	Neoniti	*P*-value
		Mean(SD)	Mean(SD)	
Change (°)	Rotation	3.76 (2.12)	2.86 (1.44)	0.205
	Reciprocation	3.50(2.67)	2.38(1.51)	0.403
% Change	Rotation	30.82(18.14)	23.55(11.64)	0.406
	Reciprocation	28.10 (22.52)	20.88 (15.52)	0.607

*: *Significant at P ≤ 0.05*

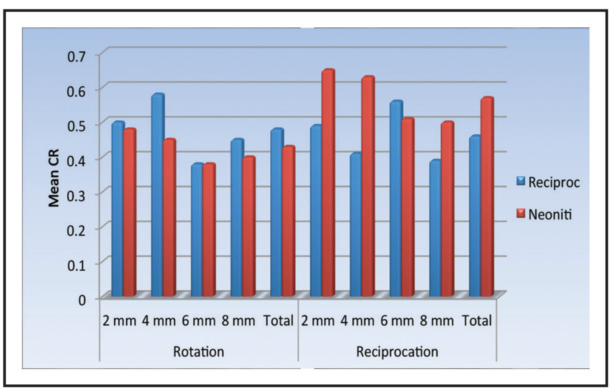

Fig. (4) Bar chart represting Centering ratio at 2, 4, 6 and 8 mm from the apex in Neoniti and Reciproc system.

DISCUSSION

The main objective 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 and apical canal transportation. NiTi instruments have been developed in attempts to overcome the short coming imposed by stainless steel alloy. [20]. The concept of using single file system is a new perspective for NiTi rotary file usage technique and is gaining clinical acceptance [21].

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 [22].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 precurving in difficult canal access as claimed by manufacture [23].When comparing the shaping abilities of different preparation techniques or different root canal instruments, it is of importance to have similar apical preparation diameter [24]. 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 mesiobuccal canals of the extracted human mandibular molars were selected, as it offers the advantage of three dimension nature of the root canal curvature. 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 [25, 26]. The CBCT scanning provides non-aggressive 3D information from the preoperative and postoperative images of the root canal at different levels that facilitates the evaluation of the significant parameters of root canal preparation [27].

This is first study evaluating shaping ability of the same single-file system under effect of reciprocation and continuous rotation motion for Reciproc as well as Neoniti system; such approaches eliminates the possible interventions of alloy type, file design and size of preparation and permits to analyze the pure effect of motion patterns on shaping ability [5]. By this way, 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 experimental study showed that, **in regarding to canal transportation**. There was no statistical significant difference among the subgroups at three studied levels (2, 4, and 8 mm from the root apex) in both BL and MD directions ,either in comparison between motions within the same file or between the two file system in full rotation ,reciprocation and manufacuture motion. However at 6mm level Neoniti CM peroduced significantly more amount of canal transportation than Neoniti RM in MD direction.

Neoniti (CM) at 6 mm significantly removed 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 [28], Resulting in more friction that worsened with continuous engagement of dentine during continuous rotation motion of Neoniti with more incidence of apical transportation [20]. 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 sequentially used files are introduced into the canal at the full working length to prepare the whole canal [22, 23].

This finding come in concidence with Chapela et al, who 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]. Similar findings were reported by Yoo and Cho, where wave one reciprocating system maintains original canal contour better than files with continuous rotation, which tend to transport the outer canal wall of the curve in the apical part of the canal [30]. According to the study of Wu et al [31], apical transportation of more than 300 mm could negatively affect the sealing of the obturation, and none of the transportation values in this study exceeded this critical limit.

Regarding to centering ability, none of the tested instruments remained perfectly centralized within the root canal.with no stastical significant differences were observed among the subgroups. However at 2and 4mm Neoniti RM produced significantly more centered canal preparation than Neoniti CM and Reciproc RM in both BL and MD dimension. This finding comes in agreement with 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 [32]. This may be attributed to that Reciproc has a sharp double-cutting edge and S-shaped geometry while Neoniti files have non-homothetic rectangular cross sections with rounded Gothic tips [33]. Furthermore, Neolix files do not show the usual metallic memory and tendency to rapidly return to straight position. 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 [34, 35].

Reciprocating movements may reduce the screw-in effect because a momentary clockwise rotation (opposite direction to active direction) 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 [36]. On other hand, The findings of this experimental study are inagreement 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 [34].

Regarding to change in curvature radius, There was no statistical significant difference between the mean value and standerd deviation of changes as well as % changes in canal curvature angle with the two systems .This finding comes in agreement with **Madani** [37] who reported that there were no significant differences between the groups in terms of the change in canal angle. The Neolix system produced less canal deviation at 7 of the 12 measuring points.

CONCLUSION

The motion pattern has an impact on the shaping ability of the severly curved root canal. Reciprocation motion enhances transition of the file inside the canal with minimal procedural errors. Neoniti and Reciproc preserve the root canal anatomy in term of apical transportation and centering ability and Radius change.

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