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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF THE CANAL TRANSPORTATION BETWEEN THREE SINGLE-FILE SYSTEMS, HYFLEX EDM, S-ONE AND NEOLIX NEONITI, USING CONE-BEAM COMPUTED TOMOGRAPHY (CBCT): AN IN-VITRO STUDY

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ABSTRACT

Aim: To compare the canal transportation using three different rotary and reciprocating single file systems. Subjects and methods: Sixty mesiobuccal roots of human permanent maxillary molars free of caries, cracks and restoration were taken. Pre and post instrumentation CBCT scans of all the roots were taken. Instrumentation was performed with the help of Hyflex EDM, Neolix Neoniti and S-One endodontic files. All the roots were examined at 3, 5 and 7mm from the radiographic apex. **Results:** At the coronal 7mm from the apex there was no significant difference between the files. At the middle 5mm S-One performed better than both the rotary file system, while at the apical 3mm all three file systems showed significant results as S-one performed better than Hyflex EDM followed by Neolix Neoniti. **Conclusion:** S-One single reciprocating file preserved better canal anatomy than both the other rotary file systems.

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INTRODUCTION

The objective of endodontic treatment is to clean and shape the root canal system, maintaining its original configuration (Gergi, 2010). The curvature of the canal is considered to be a preeminent risk factor for procedural errors such as ledging, zipping and transportation. This is due to the tendency of endodontic instruments to straighten within the canal during chemo mechanical preparation (Peters, 2003). Successful endodontic therapy depends on effective debridement and shaping of the root canal system without deviating from the original anatomy. Ideally, during root canal preparation, the instruments should always confirm to and retain the original shape of the canal to maximize the cleaning effectiveness and minimize unnecessary weakening of tooth structure to achieve the optimal result. When curvatures are present, preparation becomes difficult and there is a tendency for all preparation techniques to divert the prepared canal away from the original axis. Transportation of the root canal is a frequent mishap during the instrumentation of curved root canals. Transportation in the apical third of the root canal promotes the harboring of debris and residual microorganisms as a result of insufficient cleaning of the root canals and destruction of the integrity of the root. The etiology associated with an increased risk of canal transportation includes insufficiently designed access cavities, use of inflexible instruments, instrumentation technique, tip design, insufficient irrigation during mechanical enlargement, degree and radius of a canal curvature, unseen canal curvatures in two-dimensional (2-D) radiography, and skill of operator (Ingle, 2002). In the past, methods for assessment of canal transportation, remaining dentin thickness, and centering ability included radiographic method, serial sectioning technique, photographic assessment, Scanning Electron Microscope, and computer manipulation technique. These methods were invasive in nature and accurate repositioning of pre- and post-instrumented specimens was difficult, whereas radiographic method provides 2-D images of 3-D objects (Dowker, 1997; Gluskin, 2001). Recently, a nondestructive technology has been advocated for pre- and post-instrumentation evaluations of canal. Cone beam computed tomography (CBCT) utilizes a cone-shaped X-ray beam and an area detector that captures a cylindrical volume of data in one acquisition. Advantages of CBCT are that it can render cross-sectional and 3D images that are highly accurate, high resolution, fully quantifiable and provides repeatable results (Garip, 2001; Arora, 2014; Maitin, 2013). Neoniti A1 (NEOLIX, Châtres-la-Forêt, France) is one of the single-file systems with full rotary motion.

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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 its manufacturer, the wire-cut electric discharge machining mechanism allows a sharper edge as well as much greater flexibility (Moazzami, 2016). This system is applied with a single-length preparation procedure that allows canal preparation at working length with a disposable single file. If proved efficient and safe, such simplified single-file instrumentation systems are favorable because of their ease of use. However, this system is not assessed yet except in a recent study (Moazzami, 2016) and this allegation should be proved by further investigation.

HyFlex® EDM (Coltene) is a new rotary system developed recently. Due to its controlled properties HyFlex® EDM files follow the anatomy of the canal, which can significantly reduce the risk of ledging, transportation and perforation. The built-in shape memory of HyFlex® EDM files prevents stress during canal preparation by changing their spiral shape thus preventing formation of microcracks and root dentin defects (Sankhe, 2017). Another single file system recently introduced in the market is S-One (Shanghai Fanta Dental Material Co.,Ltd). S-One is manufactured using AF (austenite finish) temperature. S-One has special heat treated wire which provides greater resistance to cyclic fatique. It has reduced screwing effect and decreased instrument stress.

MATERIALS AND METHODS

This in vitro study was performed on mesiobuccal (MB) roots of 60 human maxillary molars (extracted for treatment purposes only). As the inclusion criteria, all teeth had to have a root length of 12 mm as well as more than 25° curvature greater than according to Schneider's method (Maitin *et al.*, 2013; Hartmann, 2007' Nazari Moghadam, 2014) The teeth were stored in 2.5% sodium hypochlorite (NaOCl) for 2-3 hours and then stored in saline at 4°C, until the start of the procedure. After access cavity preparation, a#10 K-file (Mani, Tochigi, Japan) was placed inside the canal until emergence of its tip through the apical foramen. The working length was determined by subtracting 1 mm from the full length of the inserted K-file when the tip of the file was just visible from the apical foramen. Before canal preparation, a CBCT image was taken from each tooth using a NewTom VG 9000 CBCT device (Quantitative Radiology SRL Co., Verona, Italy), at 110 kVp, 0.100 mm axial thickness, and 9.5 mA and 75×75×75 µm3 voxel size (Maitin *et al.*, 2013).

The teeth were assigned randomly to three groups (n=20).

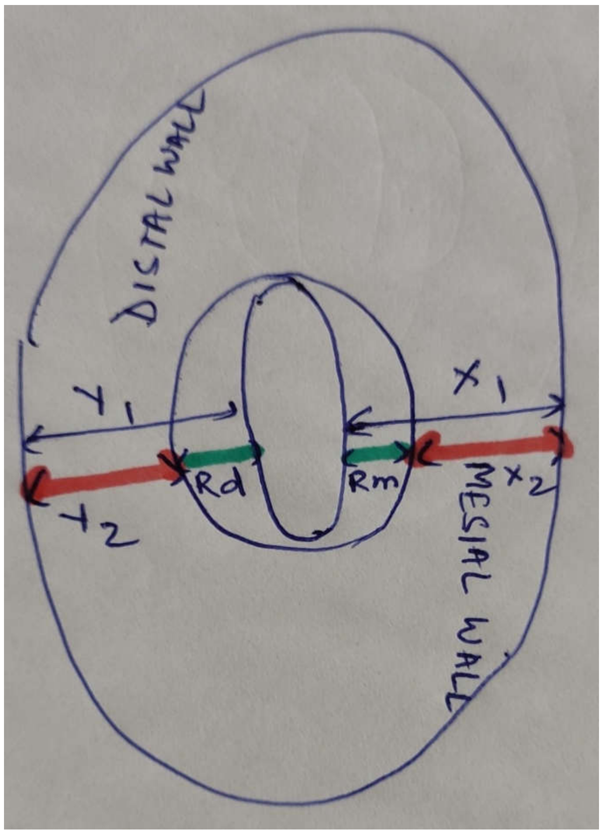
Group 1: HyFlex EDM (Dentsply, Tulsa Dental, Tulsa, OK, USA)
Group 2: Neolix Neoniti (Neolix Creative Dental Instruments, Châtres-la-Forêt, France)
Group 3: S-One (Shanghai Fanta Dental Material Co., Ltd)

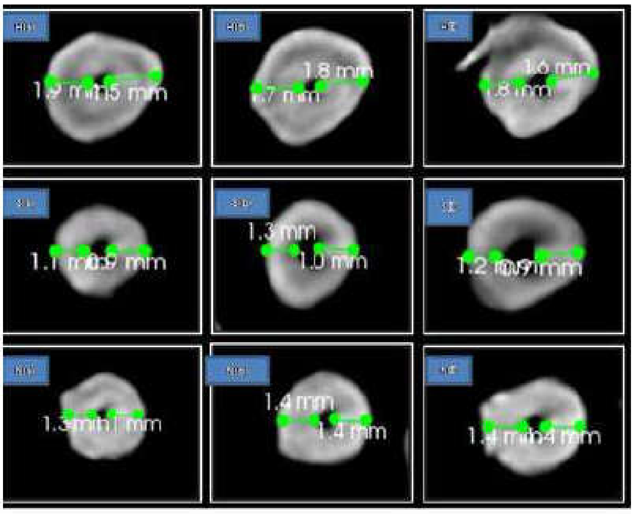
An endodontist carried out the root canal preparation procedure using 2.5% NaOCl irrigation establishment of apical patency with a #10 K-file. In the first group the preparation was performed using Hyflex EDM instruments (Dentsply, Tulsa Dental, Tulsa, OK, USA). In the second group, the samples were prepared using Neoniti A1 (Neolix Creative Dental Instruments, Châtres-la-Forêt, France) instruments. In the third instrumentation was done with S-One reciprocating endodontic file. In all the groups the procedure was done using RC Prep lubricant (Premier Dental Products, Philadelphia, USA) and 2.5% NaOCl for irrigation. After preparation, the pre- and post-instrumentation CBCT images were taken with similar parameters. The images were evaluated using the Newtom scanner software (Newtom, Verona, Italy), for post-instrumentation changes.

The canal transportation at each of the sections pertaining to each of the 60 teeth, was measured using the following formula: (Y1–Y2)–(X1–X2) (Gergi, 2010; Nazari Moghadam, 2014; Short, 1997) (Figure 1), where Y is the shortest distance between the canal's distal periphery and the root's distal periphery (i.e., the thickness of distal canal wall), and X is the shortest distance between the canal walls and root mesial peripheries (mesial canal wall thickness). The first and second values represent the pre instrumentation and post-instrumentation measurements, respectively. The outcome of each parentheses block is the extent of canal wall removal in distal and mesial direction. Hence, a zero total outcome would mean the lack of canal transportation, while positive and negative outcomes would mean distal and mesial transportations, respectively.

RESULTS

Evaluation of canal transportation was done at three levels between three groups i.e 7mm there was no significant results. At middle third i.e 5mm S-one performed better than both the rotary files but both the rotary files showed no statistically significant difference while at the apical 3mm level all the files showed statistically significant results where S-one showed least canal transportation followed by Hyflex EDM and Neolix Neoniti(Figures 2 and 3) (Tables 1,2 and 3).





Post Instrumentation

H(a),(b),(c);S(a)(b)(c) and N(a)(b)(c) represent CT images after instrumentation with Hyflex EDM, S-one and Neolix Neoniti at 3,5 and 7mm respectively

Table 1: Canal transportation at coronal 7mm

At coronal end:7 mm		Mean	Std. Deviation	P value
Mesial	S one	-0.20	0.13	0.363
	Hyflex edm	-0.33	0.10	
	Neolix	-0.25	0.15	
Distal	S one	-0.18	0.08	0.620
	Hyflex edm	-0.18	0.13	
	Neolix	-0.13	0.08	

One way anova, level of significance set at $p < 0.05$

Table 2: Canal transportation at middle 5mm

At middle end:5 mm		Mean	Std. Deviation	P value
Mesial	S one	-0.08	0.07	0.001* S one>hyflex>neolix
	Hyflex edm	-0.36	0.11	
	Neolix	-0.88	0.23	
Distal	S one	-0.02	0.01	0.001*, S one >neolix, Hyflex>neolix
	Hyflex edm	-0.18	0.09	
	Neolix	-0.93	0.40	

One way anova, level of significance set at $p < 0.05$

Table 3: Canal transportation at apical 3mm

At apical end:3 mm		Mean	Std. Deviation	P value
Mesial	S one	-0.04	0.06	0.048 S one>hyflex> neolix
	Hyflex edm	-0.18	0.24	
	Neolix	-0.45	0.52	
Distal	S one	-0.06	0.04	0.013 S one>hyflex> neolix
	Hyflex edm	-0.32	0.16	
	Neolix	-0.25	0.16	

One way anova, level of significance set at $p < 0.05$

DISCUSSION

The present study aimed to compare the root canal transportation using S-One, Hyflex EDM and NeoNiTi single-file systems in curved roots of maxillary first molars using CBCT. CBCT imaging is a noninvasive, relevant process for the analysis of canal geometry and shaping techniques (Elnaghy, 2014). In the present study, CBCT was used to evaluate the shaping performance of the tested groups. However, shaping of curved canals has been offset by a tendency for all preparation techniques to deviate the prepared canal from its original axis. Deviation from the original curvature can lead to excessive or inappropriate dentine removal, straightening of the canal and creation of a ledge in the dentinal wall, a biomechanical defect known as elbow, which forms the coronal to the elliptical-shaped apical seal, canals with hourglass appearance in cross-section, which requires stripping and over-preparation that weakens the tooth, resulting in fracture of the root (Marzouk, 2013) . The mesiobuccal root of maxillary first molars was chosen as they usually present with remarkable curvatures and have mesiodistal flattening (Gani, 1999). Teeth having root curvature ranging from 15° to 30° were selected. Curved canals were selected for this study because they present greater challenges to instrumentation (Zhao, 2014). The creation of a glide path is essential to allow the proper action of NiTi instruments either used in a rotary or reciprocating motion.[18] A mechanical or manual glide path is key to reducing the effect of torsional stresses along the canal, the screwing effect of rotary instruments, and the risk of instrument failure.[19] Furthermore, a glide path created mechanically might be faster and associated with a lower prevalence and severity of postoperative pain.

The single use of endodontic instruments has further supported to reduce instrument fatigue and possible cross-contamination associated with the use of NiTi rotary instruments for canal instrumentation (Azarpazhooh, 2008). In the present study, three levels were chosen: 3, 5 and 7 mm. These measurements represent the apical, middle and coronal thirds of root canals where curvatures with high vulnerability to iatrogenic mishaps typically exist. The amount of canal transportation increases with apical preparation greater than size 25 (Shivashankar, 2016); hence, the apical preparation was limited to size 25 file in the present study. In the present study, at 3 mm mesiodistally, the transportation is more with Neoniti and hyflex EDM than S-One, which was statistically significant. Berutti *et al.* have reported that reciprocating movement allows a more centralized chemo mechanical preparation when compared to continuous rotary motion, especially in the apical third (Berutti, 2012). To overcome the root curvature, 'balanced forced technique' was proposed by Roane *et al.* in 1985.[23] Reciprocal action is the specially designed to work in a similar manner but in a reverse balanced force motion. A large rotating angle in the counter clockwise motion determines the instrument advances in the canal and engages dentin to cut it, whereas a smaller angle in the clockwise motion allows the file to be immediately disengaged and safely progress along the canal path, while reducing the effect of a screwing effect and file breakage. These angles are specific for the different instruments. At 5mm S-One performed better than both the rotary system. Cross section of Neoniti is a homothetic rectangle, the built-in abrasive property of the flutes, hard cutting edges, circumferential brushing motion in the middle, coronal third and pecking motion in apical third, may have led to aggressive cutting and caused canal transportation (Forghani, 2017). At 7mm there was no significant difference between all three files. When considering the apical third of the canal (points 1–3), the instrumentation with continuous rotation produced a greater enlargement of the canal compared with the reciprocating motion ($P < .05$). This can be explained with the number of total rotations that the instruments do while shaping the canal. Whereas the instruments make a 360^0 turn for every cycle in the continuous movement, in the same timespan with the reciprocating movement, the instruments do a 20^0 turn. In the apical third of the canal there are statistically significant differences on both the inner and the outer sides of the curve. On the outer side the continuous movement produced a greater enlargement of the canal; conversely, on the inner side the reciprocating movement enlarged more. This can be explained with the observation that the continuous movement shifted toward the outer part of the curve, thus minimally shaping the inner part of the curve and resulting in a preparation that experienced transportation. The reciprocating movement shaped a preparation in a more uniform manner centered on the original canal, and so it enlarged almost equally in both the inner and outer directions. This action would result in a greater contact area between the instrument and the canal walls, thus producing a debridement quality as effective as the continuous rotation when considering round canals (Franco *et al*., 2011)

Conclusion

Within the limitations of this in vitro study, it was concluded that at coronal part all files exhibited canal transportation. While at the middle and apical third S One performed better than Hyflex EDM and Neolix Neoniti.

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