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PULP VOLUME CHANGES AFTER ROOT CANAL PREPARATION WITH THREE SINGLE NICKEL TITANIUM FILES USING CONE BEAM COMPUTED TOMOGRAPHY: A RANDOMIZED CLINICAL TRIAL

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ABSTRACT

Background: Single nickel-titanium (NiTi) files have been introduced in the endodontic market and used as only one instrument in various cases to prepare the entire root canal.

Aim: changes in pulp volume in root canals of mandibular molar teeth were determined using cone-beam computed tomography (CBCT) after root canal preparation using three different single NiTi files (Reciproc Blue, XP-endo Shaper, and One-Shape).

Materials & Methods: This trial included forty-five patients have first mandibular molars with a mesiobuccal canal curvature range of (25-35°), and distal oval canals. They were then allocated into three equal groups corresponding to the type of files used in the root canal instrumentation (Reciproc Blue, XP-endo Shaper, and One-Shape). Pre- and post-instrumentation scans were performed to match the pulp volumes from CBCT images. One-way ANOVA was used to identify possible differences in canals among groups corresponding to the instrumentation.

Results: There was a significant difference in the volume change in the distal canals between the groups (D). There was no significant difference in the volume change between the mesiobuccal (MB) and mesiolingual (ML) canals. For the distal canal, there was a significant difference between XP-endo Shaper and Reciroc Blue (p=.008) and between XP-endo Shaper and One-Shape (p=.001). However, no significant difference in volume change was noted between the Reciroc Blue and One-Shape.

Conclusion: The Reciproc Blue, XP-endo-Shaper and One-Shape files were equally effective in shaping the radicular part of mesial canals, XP-endo Shaper was more effective in shaping oval distal canals than Reciproc Blue, and One-Shape.

Keywords: CBCT, Pulp volume, Root canal preparation

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INTRODUCTION

Endodontic treatment is built on chemo-mechanical preparation and obturation of the radicular root canal system [1]. After preparation, the root canal may gain a uniform funnel-tapering shape by preserving its unique outline [2]. In addition, these goals are frequently challenging to achieve because of canal curvatures and unpredictable root canal anatomy [3].

At 2011 the first initiation of the Reciproc system that gives approval for use one single-file nickel-titanium (NiTi) in endodontic practice [4]. The files of this system are the only instruments used to prepare root canals in various cases [5, 6].

Reciproc Blue system maybe in the right place to form a novel invention of single reciprocating file. Its fabrication is achieved by heat treatment of M-Wire, which modifies the molecular structure of the file to increase its flexibility [7]. The file has S-shaped cross-section, including a non-cutting tip and two cutting edges. Therefore, this unique design is required to increase flexibility, cyclic fatigue resistance, and surface microhardness [8].

XP-endo Shaper (XPS) (30/.01) is also one file constructed from MaxWire alloy that permits the instrument to modify its phase according to temperature changes. At 20 °C, XPS revealed the martensitic phase. At the body temperature inside the canal, XPS changed to an austenitic phase. Booster tip with six cutting edges. Root canal instrumentation began with a glide path of at least a #15 K file. The booster tip design enabled the XPS instrument to progressively shape the canal, reaching a size of 30/.04 [9].

One-Shape file operates with a constant rotational movement that provides higher cutting efficacy. This single file has a varying cross-section along its blade. Electropolishing may increase file flexibility [10]. One-Shape file also has anti-breakage control, which improves its fracture strength. This file has a tip size of ISO 25/.06, varying pitch, and a safe non-cutting tip [11].

Cone-beam computed tomography (CBCT) performs san important role in the field of dentistry. It can be used for various purposes including diagnosis, treatment, and follow-up. Axial, coronal, and sagittal CBCT sections can be used to measure pulpal dimensions. By reformatting and segmenting CBCT images, volume changes in the pulp can be precisely and correctly measured [12].

The goal of this study was to assess changes in pulp volume after preparation with three different single NiTi files (Reciproc Blue, XP-endo Shaper, and One-Shape) using CBCT.

METHODS

Patients Selection

This study was achieved at the Department of Endodontics, Faculty of Dentistry, Suez Canal University, and approved by the Faculty of Dentistry Human Research Ethics Committee (Approval No. 210/2019).

Subjects were selected from a group of healthy patient's age range from 30 to 45 years who required root canal treatment (RCT) of permanent mandibular first molars. The clinical procedures, study purpose, and benefits/risks of the procedures were explained to each patient. Prior to the start of the treatment, each patient signed a written informed consent form.

- The inclusion criteria

The mandibular arch of all patients was scanned using CBCT to include the mandibular first molars, which were diagnosed with symptomatic irreversible pulpits. These molars had completely formed apices and mesial roots with two separate orifices that terminated in two separate foramina (type IV Vertucci canal configuration). Mesial canal curvature ranged between 25º and 35º according to

Schneider's technique [13]. When the buccolingual maximum diameter, measured 5 mm from the root apex, was twice as large as the mesiodistal maximum diameter, the distal root canal was considered oval [14].

- The exclusion criteria

Pregnant women, immunocompromised patients, patients with complicated systemic diseases, teeth requiring post and core, calcified root canals, non-restorable teeth, mobile molars, existence of a sinus tract, swelling of soft tissues, and radiographic appearance of internal or external resorption were excluded.

Root canal preparation

All patients had a single endodontist who took their dental and medical history, performed the clinical examination, and achieved the RCT procedures. (Leica Microsystems, Wetzlar, Germany). Molar teeth were anesthetized with 4% articaine HCl and 1:200,000 adrenaline (Septodont, Novocol Pharmaceutical, Canada, Cambridge, ON, Canada). A rubber dam was used to keep the teeth isolated with a rubber dam and clamps were wiped with 2% chlorhexidine (Consepsis V, Ultradent Products, South Jordan, UT, USA).

A sterile high-speed tungsten carbide bur was used to prepare the initial access cavity (Dentsply, Maillefer) under copious amounts of water-cooling. A sterile Endo-Z bur (Dentsply, Maillefer) was used to open the pulp chamber.

The working length of each root canal was verified using an electronic apex locator (Raypex 6 (Munich, Germany). The lip clip was secured to the patient's lip, and the apex locator electrode was connected to a stainless-steel ISO #15 K file inside the root canal. As long as the Raypex 6 display showed the apical foramen, the file was subtracted 0.5 mm from this measurement to obtain the actual working length (AWL).

Root canal instrumentation was achieved by one operator, strictly following the instructions of manufacturers for the three main instruments using a VDW silver endomotor (VDW GmbH, Munish, Germany). All patients were randomly and equally allocated into three groups corresponding to the single file used in the root canal instrumentation (n=15). First, a Proglider file (Dentsply Maillefer; Ballaigues, Switzerland) provided a mechanical glide path. During root canal preparation, an ISO #15 K file was used for frequent recapitulation and 2.5% sodium hypochlorite irrigation was applied after each instrument with a side-vented needle gauge #30. Glyde was used as a lubricant (Dentsply, Maillefer).

1. Reciproc Blue

Reciproc Blue (25/.08) (RPC Blue; VDW, Munich, Germany) was operated in a reciprocating working motion (150°/30° clockwise/counterclockwise) generated by a torque- controlled electric motor with a 6:1 contra-angle hand piece. A slow in-and-out pecking motion with an amplitude of less than 3 mm was used. After obtaining three peaks, the instrument flutes were cleaned. The instrument was removed after navigating the canal's working length and freely rotated. Each file was used to prepare four canals, corresponding to a single use.

2. XP-endo Shaper (XPS)

XP-endo Shaper (30/0.01) (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) was operated at 1000 rpm and 1 Ncm torque, using a single instrument per canal. The file was also used in three cycles, each consisting of 10 in-and-out motions with an amplitude of 3–4 mm to reach the working length.

3. One-Shape

One-Shape instrument (25/.06) (Micro Mega, Besancon, France) was set to 350 rpm and 5 Ncm.

This file operates on the basis of three distinct cross–section zones, the first of which has a variable design with 3-cutting edge, the second of which has a cross–section that subsequently transforms from three to two cutting edges, and the third has two cutting edges. This resulted in high cutting action in the three zones of the canal.

CBCT Scanning

CBCT scans were taken (i) before inclusion of the patient in the trial and before initial root canal instrumentation and (ii) after root canal instrumentation. The raw DICOM dataset obtained from the CBCT machine (Scanora 3D Soredex, Helsinki, Finland) was initiated using a special third-party software (Ondemand 3D, Seoul, South Korea) for secondary reestablishment.

The CBCT machine used in this study was characterized as follows. The detector of this machine was composed of CMOS flat panel with isotropic voxel size 0.25 mm. The arches were scanned using X-ray tube retain a current intensity 16 mA, Kilo voltage 85 Kvp and a focal spot size 0.5 mm with target angle 5 degrees. The scanning time was 10 s of pulsed exposure, resulting in an effective exposure time of 2.5 seconds to scan a field of view (FOV) of 7.5 cm height x 14.5 cm and width x 14.5 cm depth. The FOV was adjusted using three guided laser light beams that centralize the area The results obtained from the datasets were compared to each other, and images were acquired in a process called "image acquisition" on a computer connected to the cone beam machine where these images are called "basis images".

The basis images were then transferred to the secondary workstation to a special software (Scanora 4.2, Sorredex Finland) through a network where the "Image reconstruction" was carried out. Image reconstruction was performed using a third-party software (Ondemand3D ver.1.0.9, Cybermed, Korea).

ITK-SNAP® software was used to assess the volume. All DICOM images were imported into the open-source software ITKSNAP® 2.4 (http://www.itksnap.org/pmwiki/pmwiki.php). To eliminate air, crowns, and other roots outside the region of interest (ROI) and achieve faster segmentation, the active contour (snake) segmentation mode was used. The pre-segmentation mode was called "Thresholding," and the root canal segmentation threshold was fixed between "1024" and "1200" Following segmentation, 0.4 mm radius bubbles were placed inside the "white" area, which represents multiple root canal spots, and contour evolution was performed [15-18].

Following the completion of the segmentation process, the software generated a three-dimensional (3D) model as well as a table displaying the volume of this structure in mm3, which was calculated.

The software tool was used to outline the ROI, isolating the root canals of the teeth to investigate each mandibular first molar canal separately, distal, mesiolingual, and mesiobuccal canal at a time, using multiplanar reconstruction (MPR) axial, coronal, and sagittal planes. Using a semiautomatic tool (Fig. 1). The images were evaluated by three dentomaxillofacial radiologists with a minimum of 10 years of experience. All the radiologists were blinded for the type of files used at the time of evaluation.

Statistical analysis

The data were parametric and normally distributed, as demonstrated by the Shapiro-Wilk normality test. Bar charts are graphical representations of the data. One-way ANOVA was used to identify possible differences in canals among groups (Reciroc Blue, XP-endo shaper, and One-Shape), supported by multiple comparisons (post-hoc test) between each of the two groups using Bonferroni correction, if significant differences were found. SPSS statistical package for social science version 25 (SPSS Inc.,

Chicago, IL, USA) was used for data analysis. P was considered significant if it was less than 0.05 with a 95% confidence interval.

RESULTS

A summary of the ANOVA results between the groups in different canals is showed in Table (1). Only in the distal canal there was a significant difference in volume change between the groups (D). Volume changes in mesiobuccal (MB) and mesiolingual (ML) canals were not significantly different.

Descriptive statistics, including the mean and standard deviation of pulp volume changes in each group in different canals, are shown in Table 2. Multiple comparisons of volume changes between the groups are shown in Table (2) and Fig (2). For the distal canal, there was a significant difference between XP-endo Shaper and Reciroc Blue (p=.008) and between XP-endo Shaper and One-Shape (p=.001). However, no significant difference in the volume change was recorded between Reciroc Blue and One-Shape.

TABLE (1) Summary of ANOVA between groups at different canals.

		Sum of Squares	Mean Square	F	P-value
MB canal	Between Groups	.421	.211	.501	.629
	Within Groups	2.524	.421		
ML canal	Between Groups	1.122	.561	.617	.571
	Within Groups	5.454	.909		
D canal	Between Groups	20.649	10.325	18.163	.003*
	Within Groups	3.411	.568		

p is significant at 5%.

TABLE (2) Comparison of volume change between groups at different canals.

	MB canal		ML canal		D canal	
	Mean	***SD***	***Mean***	***SD***	***Mean***	***SD***
XP-endo Shaper	2.92 **A**	1.01	3.50 **A**	1.49	5.74 **A**	1.03
Reciroc Blue	2.93 **A**	.45	2.70 **A**	.67	2.74 **B**	.51
One-Shape	2.47 **A**	.17	2.82 **A**	.23	2.35 **B**	.62
One Way ANOVA (p value)	.629		.571		.003*	

p is significant at 5%. Different letters denote significant difference between each 2 groups (Bonferroni test <.05). Similar letters denote no-significant difference between each 2 groups (Bonferroni test >.05)

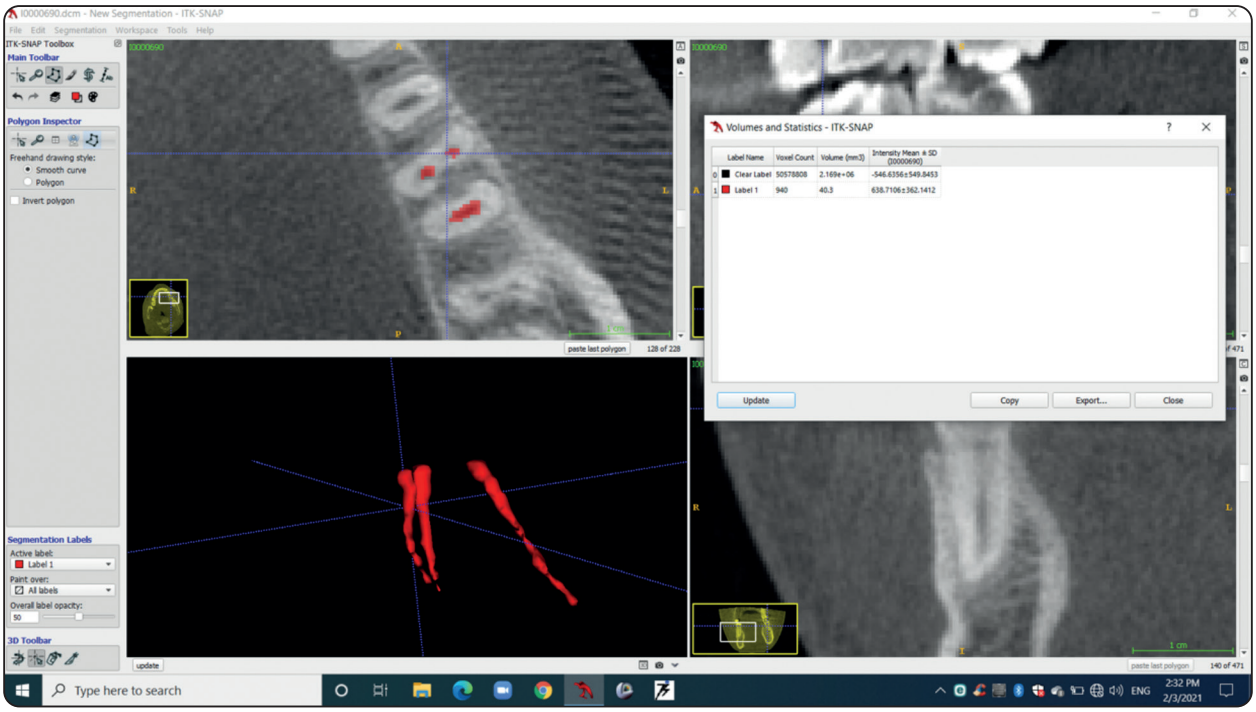

Fig. (1): The software tool used to delineate the region of interest (ROI), isolating root canal of the teeth to be investigated mandibular first molar each canal separately.

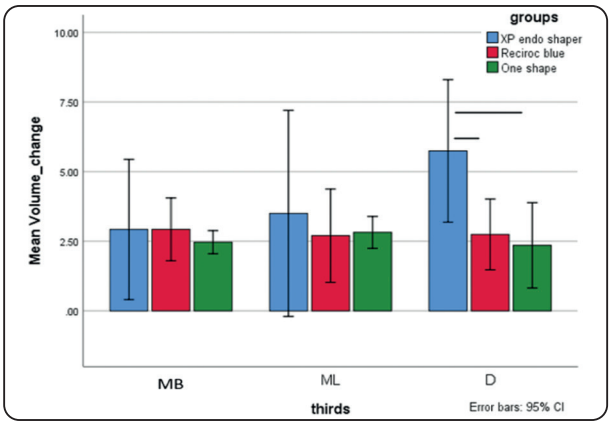

Fig (2): Comparison of volume change between each 2 groups at different canals. Line connecting bars indicate significant difference between each 2 groups.

DISCUSSION

In dental practice, the quality of the instruments used for the treatment of molars is important [19]. This study evaluated the pulp volume changes in the root canals of mandibular molar teeth after preparation with three different single NiTi files (Reciproc Blue, XP-endo Shaper, and One-Shape) using CBCT.

The degree of root canal curvature, shape, preservation of the coronal structure, working diameter, root thickness, and presence or absence of pathological lesions related to the roots must be considered when choosing a file system for proper preparation of the root canal [20].

The mandibular first molar was chosen for its anatomy, in which the mesial canals, MB, and ML exhibited considerable curvature. The tool was subjected to repetitive stress when a single instrument is used to prepare the root canal. A combination of anatomical factors and instrument stress can result in distortion [21].

In addition, the distal roots of mandibular molars and root canals with distal oval-shaped cross sections present a distinct issue [22]. According to existing knowledge, the preparation of such canals leaves some canal surfaces unaffected [23].

Several studies have compared the pulp volume of various instruments; however, these studies compared variations based on the use of canals with more intricate anatomies rather than variations in the preparation procedure, as in the current study [24].

The application of CBCT scans for pulp volume measurement has great benefits compared to 2D techniques, as CBCT is a simple technique that offers an objective criterion and is valid for a wide range of subjects or specimens with no need for tooth extraction or tooth sectioning [25].

When using automated instruments for root canal preparation, a glide path must be created to allow the instrument to slide into the canal, thereby decreasing the tension and torsion effects on the rotary instrument a Proglider file was used [26].

In this study, there was no significant difference in pulp volume changes in the ML and MB canals between the groups, regarding D canal there was a significant difference in the D canal between the groups. XP-endo Shaper showed significant high pulp volume changes in oval D canals than Reciproc Blue, and One-Shape. These results were consistent with those reported by Smidar et al. [27] and Poly et al. [28].

The benefits of using NiTi instruments for root canal preparation have been well established. Nonetheless, the cutting ability depends on many parameters, including cross-sectional design, debris elimination capability, helical and rake angles, metallurgical qualities, and instrument surface treatment. The cutting efficiency of an instrument depends on the main features of the cutting edges that form the active part of the instrument, which is defined as the spacing between two edges, helix, and cutting angles that form the depth of the grooves and orientation of the edges [29, 30].

All the used files were equally effective in shaping the radicular part of mesial canals, as reported by Adıguzel and Tufenkci [31] the Reciproc Blue file specific qualities were due to the heat treatment utilized throughout the fabrication process that altered their molecular structure and increased its strengthened and flexibility.

Because of the varied cross sections along the length of the file, one-shape files for curved canals enable greater cutting activity around the three zones of the root canal. In addition, owing to its high cutting efficiency and suppleness, it improves apical advancement, which is in agreement with the results of Dhingra et al. [32].

The equilateral triangular cross-section of the XP-endo Shaper facilitated instrumentation of irregular canal walls and improved irrigation in the apical area of the canal. The XP-endo Shaper instrument had a consistent cutting action. Its frequent contraction and expansion inside the canal might aid in dislodging pulp remains, which may be due to file expansion leading to improved cutting [33].

However, some studies have shown no significant difference in the preparation of oval canals using XP-endo Shaper [34, 35].

One of the study's limitations was the small number of included subject, and the available CBCT machine model with isotropic voxel size 0.25 mm was used.

Further studies should be conducted with larger sample sizes and a combination of files to improve the shaping of the oval-shaped canals.

CONCLUSION

The Reciproc Blue, XP-endo Shaper and One-Shape systems were equally effective in shaping the radicular part of mesial canals, XP-endo Shaper was more effective in shaping oval distal canals than Reciproc Blue, and One-Shape.

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Conflicts of interest

The authors declare no conflicts on interest in relation to this study.

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