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EVALUATION OF THE SHAPING ABILITY OF EDGEFILE X-7, XP-ENDO SHAPER AND TRUNATOMY ROTARY FILES IN MESIOBUCCAL CANALS OF LOWER MANDIBULAR MOLARS USING CONE BEAM COMPUTED TOMOGRAPHY (IN-VITRO STUDY)

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ABSTRACT

INTRODUCTION: The main aim of mechanical instrumentation during root canal treatment is to remove the inner layer of dentin to facilitate removing of all bacteria and smear layer from the canal. New rotary files designs allow more contact to canal walls to improve canal cleaning and shaping.
AIM OF STUDY: The goal of this study was to assess the shaping ability of EdgeFile X-7, XP-endo shaper and TruNatomy rotary files in mesiobuccal root canals of mandibular molars using cone beam computed tomography (CBCT).
METHODS: Thirty unidentified extracted roots of human mandibular molar teeth of mild root curvature were selected for this study. Chemo-mechanically preparation of all the teeth were done using three different nickel titanium (Ni-Ti) rotary file systems. The teeth were divided randomly into three groups (n=10 each) according to the rotary files used in preparation procedure as follows: Group I: EdgeFile X-7, Group II: XP-endo shaper, Group III: TruNatomy. The incidence of canal transportation and centering ability by these rotary files' instrumentation were assessed using CBCT pre and post scanning.
RESULTS: Variation in canal transportation and centering ability between groups were compared using Kruskal Wallis test and Freidman test at three mm, six mm, and nine mm levels within all groups. Significance level was set at P value equal 0.05. Showing no significance difference between the three rotary files including centering ability and canal transportation.
CONCLUSION: All the three rotary systems were proved to prepare root canals with low canal transportation and good centering ability.
KEYWORDS: Canal transportation, Centering ability, EdgeFile X-7, TruNatomy, XP-endo shaper.
RUNNING TITLE: Shaping ability of three heat-treated rotary files.

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INTRODUCTION

Root canal preparation is the most important step in the root canal process, because it is challenging, time-consuming, and regulates the efficacy of succeeding procedures like as irrigation, obturation, and the overall outcome of the treatment (1, 2).
Root canal instrumentation is a critical step in root canal treatment because it preserves the natural form and main curvature of the root canals, which is especially significant in curved canals. For many years, root canal preparation was done using stainless steel (St-St) hand files, which resulted in ledge development, canal transportation, and root canal system perforation in many situations. To reduce procedural errors during root canal preparation, nickel-titanium (Ni-Ti) rotary files were brought to the market. Ni-Ti rotary files enable quicker root canal instrumentation while maintaining a high degree of safety and reducing the incidence of procedural errors (3).
Nickel Titanium rotary files have a design revolution to cuts well while resisting fracture even in the most difficult root canal anatomy. It is important not to forget that all rotary files systems have advantages and disadvantages. The kind of alloy, cross-sectional design and degree of taper, might influence instrument performance (1).
Canal transportation is a diversion from the initial canal course during root canal preparation. It is described as mismatched root canal preparation that violates the natural root canal architecture at the apical canal section and/or its coronal region. It is

mainly caused by Ni-Ti rotary files during instrumentation restoring its shape inside the canal, resulting in unequal cutting pressures along the canal length. Asymmetrical preparation might also be caused by the file's failure to remain centered inside the canal (4).

Centering ability is the ability to instrument the canal to a continuously tapering preparation that preserves the root canal anatomy, maintaining the root canal foramen narrow without deviating from the natural root canal curvature. Several methods can be used for evaluation of canal transportation and canal centering ability during biomechanical instrumentation such as computed tomography (CT), CBCT, Micro-Computed Tomography (µCT), stereomicroscopy, standardized radiography, scanning electron microscopy, silicon imprint and histologic sections can be used to assess the shaping ability of Ni-Ti rotary files (5).

This study was conducted to assess the shaping ability of EdgeFileX-7, XP-endo shaper and TruNatomy rotary files in mesiobuccal canals of lower molars using CBCT.

MATERIALS AND METHODS

Thirty humans extracted first and second mandibular molars were selected from the outpatient clinic of the maxillofacial and surgery department in Alexandria University. According to **Schneider et al.** (6) all teeth were radiographed preoperatively to assess the degree of curvature of mesial roots with mild curvature less than 25 degree and to detect any calcification or intrapulpal or intracanal abnormalities.

A Six prefabricated rectangular mold were made of acrylic resin (Acrostone Dental & Medical Supplies, Cairo, Egypt) were prepared, then newly-prepared putty consistency silicone-based impression material (Zetaplus, Zhermack, Italy) was inserted inside the mold. Each five teeth were inserted in the silicone-based material inside the mold before setting for standardization during the pre and post instrumentation and CBCT scans. Each mold was marked according to the group of rotary files used during instrumentation.

Primary CBCT images were done before instrumentation. The CBCT images were acquired using J Morita R100 device. The scans were done with field of view of width 100mm X height 40mm. The voxel size was set to be 0.125. The tube voltage was 75 KV and 1 mA with exposure time 9.4 seconds (7).

Using OnDemand 3D software (Cyber Med, USA) axial cuts were carried out at three, six- and nine-mm level from the apex respectively.

All specimens were adjusted at 18mm length to obtain reproducible reference point with flat occlusal surface using a double-faced diamond disc (Komet, USA, LLC) mounted on low-speed handpiece (8). Then all teeth were accessed by high-speed round carbide bur under cooling water until pulp penetration occurred and then a safe ended bur was used for finishing and flaring of access cavity.

The working length of the mesiobuccal root was measured using K file #10, until it was visible from the apical foramen, and then one mm was reduced from this point.

Grouping of the specimens

According to the type of the rotary file used, all teeth were divided into three equal groups.: Group I (n = 10): EdgeFiles X-7, Group II (n = 10): XP-endo shaper and Group III (n= 10): TruNatomy.

Chemo-mechanical preparation of mesiobuccally root canals

- After coronal straight-line accesses to the canal orifices were established. All mesiobuccal canals were preflared to the working length using St-St K-files of size #10, 15 with the aid of EDTA gel (META, Chung Buk and South Korea) to obtain a manual glide path. The canals were irrigated during the preparation and after each file by 5% NaOCl using 30G side vented syringe (Endo-Top, Cerkamed, Poland).
- During instrumentation, all teeth molds might emerge in water path at 37℃ to provide perfect conditions for files expansion.
- Endo gold endodontic motor was adjusted according to manufacturer instruction for each file system

Group I: EdgeFiles X-7 system was adjusted at 300-500 rpm and torque 3 N.cm in continuous rotation motion. EdgeFile X-7 (0.17/0.04) was used to the middle third of the canal followed by (20/0.04), (25/0.04) and (30/0.04) EdgeFile X-7 were used in the same way until reaching the full working length.

Group II: XP-endo shaper file was adjusted at 800 rpm and torque 1.0 N.cm in continuous rotation motion. XP-endo shaper (#30/0.04) was introduced into the mesiobuccal canal without pressure till reaching the full working length.

Group III: TruNatomy system was adjusted at 500 rpm and torque 1.5 N.cm in continuous rotation motion. Orifice modifier rotary file (20/0.08) was introduced to middle third of the canal, then glider rotary file (17/0.02) was used and finally prime shaping file (#26/0.04) was used in the same way until reaching the full working length.

After cleaning and shaping, all teeth were irrigated using 17% EDTA solution for one minute followed by final rinse by 5% NaOCl and paper point was used for drying of canals completely.

Postoperative CBCT evaluation

Finally, all specimens were mounted on the CBCT scanner for postoperative imaging with the same settings as the preoperative scan.

Canal transportation and centering ability evaluation

Calculation of canal transportation and canal centering ability was carried out through the technique performed by **Gambill et al.** (5). All roots were scanned apico-coronally where the analysis was done up to three root levels 3mm, 6mm and 9mm from the most apical position of each specimen before and after preparation.

A) Canal transportation was calculated through the equation (X1-X2) - (Y1-Y2). A number different than "0" indicates that transportation happened.

B) Canal Centering Ability was calculated through the equation (X1-X2)/ (Y1-Y2). Where this formula was adopted to the value of numerator, which should always be lower than the value of the differences. A value of “1” was indicated perfect centering.

In both formulae, (X1) and (X2) indicated the shortest distances from the outside of the mesial surface to the border of the non-instrumented canal and instrumented canal, respectively. The shortest distances from the outside of the distal surface to the border of the non-instrumented canal and the instrumented canal, respectively, were indicated by (Y1) and (Y2).

Statistical analysis

Normality was checked using the Shapiro-Wilk test, box plots, and descriptive statistics. Canal transportation was not normally distributed. Data are presented as median, interquartile range (IQR), minimum and maximum values, in addition to mean and standard deviation (SD).

Differences in canal transportation and centering ability between groups were compared using Kruskal Wallis test. Comparisons between three mm, six mm, and nine mm levels within each group were done using Freidman test and followed by pairwise comparison with Bonferroni adjustment. Significance level was set at P value of 0.05. All tests were two tailed. Data were analysed using SPSS for windows version 23.

RESULTS

The obtained results of canal transportation were interpreted, where a value of "Zero" indicated no transportation. Also, the negative results represented transportation to the outer/mesial surface of the root curvature, while positive results represented transportation to the inner/distal root curvature. As regards to the values of centering ability, the results were interpreted where values equal to "One" indicated perfect centralization, while values equal to "Zero" indicated complete decentralization.

Concerning canal transportation, at three- and six-mm level, the EdgeFile X-7 group showed the least median value of canal transportation. Followed by XP-endo shaper file, then the TruNatomy files group showed the highest median value of canal transportation. However, there was no statistically significant difference, between all groups. (P> 0.05) While at nine mm level, XP-endo Shaper group showed the least median value of canal transportation, followed by TruNatomy files. Then EdgeFile X-7 group showed the highest median value of canal transportation. However, there was no statistically significance difference between all groups (P> 0.05). **Table (1)**

Concerning canal centering ability, At three and six mm levels EdgeFile X-7 showed better canal centering ability with highest median value, followed by XP-endo shaper while TruNatomy files showed less canal centering ability with the lowest median value. While at nine mm level TruNatomy files showed better canal centering ability with highest median value followed by XP-endo shaper while EdgeFile X-7 file showed less canal centering ability with the lowest median value. However, there was no statistically significance difference between the three rotary files at the three, six and nine mm levels. (P> 0.05). **Table (2) Fig. (1)**

Table (1): Median values of Canal transportation among the study groups at the three levels.

Root Canal Level	Edge Files X7 (n=10)	XP Endo Shaper (n=10)	TruNatomy Files (n=10)	Test (*p* value)
3 mm	-0.02 (0.05)	-0.06 (0.16)	-0.10 (0.31)	X^2= 3.597 (0.166)
6 mm	-0.02 (0.6)	-0.04 (0.15)	-0.10 (0.20)	X^2= 1.32 (0.504)
9 mm	-0.11 (0.17)	-0.06 (0.11)	-0.07 (0.17)	X^2= 1.440 (0.487)

Differences in canal transportation between groups were compared using Kruskal Wallis test. Comparisons between three mm, six mm, and nine mm levels within each group were done using Freidman test and followed by pairwise comparison with Bonferroni adjustment.

Table (2): Median Values of Centering ability among the study groups at the three levels.

Root Canal Level	Edge Files X7 (n=10)	XP Endo Shaper (n=10)	TruNatomy Files (n=10)	Test (*p* value)
3 mm	0.79 (0.48)	0.72 (0.62)	0.61 (0.72)	X^2= 1.500 (0.472)
6 mm	0.84 (0.24)	0.75 (0.45)	0.68 (0.70)	X^2= 1.121 (0.571)
9 mm	0.54 (0.43)	0.77 (0.31)	0.77 (0.51)	X^2= 1.589 (0.452)

Differences in canal centering ability between groups were compared using Kruskal Wallis test. Comparisons between three mm, six mm, and nine mm levels within each group were done using Freidman test and followed by pairwise comparison with Bonferroni adjustment.

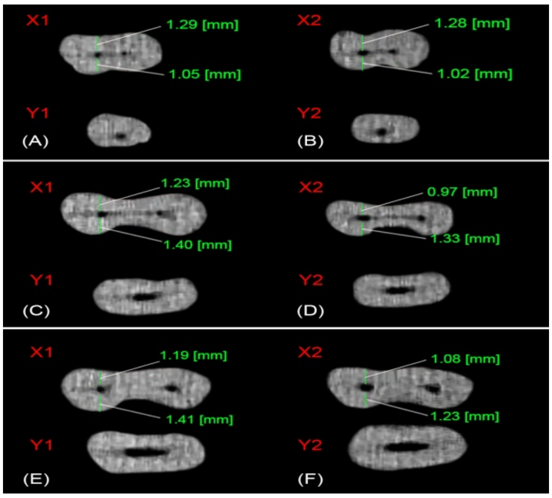

Figure (1): Showing CBCT images analysis of teeth one of the samples at three, six- and nine-mm levels. (a&b) Axial sections of pre and post instrumentation measurement at three mm level, respectively. (c&d) Axial sections level of pre and post instrumentation measurement at six mm, respectively. (e&f) Axial sections level of pre and post instrumentation measurement at nine mm, respectively.

DISCUSSION

The goal of mechanical instrumentation of root canals is to clean canal walls while preserving the natural anatomy. This results in better root canal preparation, allowing irrigation, intracanal medication, and 3-dimensional obturation (17).
In endodotic preparation, curved canals present as a challenge, since all preparation procedures have been shown to modify the root canal pathway as canals are curved mainly in the apical third (18).
Furthermore, canal curvature causes unequal dentin removal during shaping, resulting in different degrees of canal transportation. Endodontic files are made from straight metal alloy as a result, force distribution is unequal in specific contact regions, and the instrument has a tendency to modify itself inside the curved canal in straight direction (15).
Endodontic mishaps are iatrogenic errors that occur during root canal preparation. Similar to other preparation effects like ledges, strip-perforations, or severe weakening of root canal walls, zip-and-elbow creation has one feature with them all: they are all most likely the outcome of canal transportation. The latter term has been described and approximated in a number of ways, although it may be defined more generally as any undesirable deviation from the normal canal pathway (15, 19).
In the present study, mesibuccal canals of human extracted permanent lower mandibular molars were selected ,because they are generally small and curved in two planes, increasing the level of instrumentation difficulties and the incidence of canal transportation. **Nathani et al. (20) and Razcha et al. (21)** described the distal concave area in mesial root as the danger zone. It tends to decrease significantly during canal preparation and is particularly susceptible to severe weakness and iatrogenic injury such as strip perforation and canal transportation. All of these characteristics of mesiobuccal root canals of lower molars make it the tooth of choice for this study to assess the shaping ability of these rotary files system (22, 23).
To ensure standardization of all specimens, some criteria were conseidered during chosing the mesiobuccal canals of mandibular molars to be non-fused and ending with two separate foramina (Vertucci's Type IV), also canals should accommodate an initial file size #15 (24, 25). Also, the working length was standerdized to length of 18mm by occlusal reduction using double face diamond disc to eliminate any confounders which may affect the results and to obtain reproducible reference point with flat occlusal surface (26, 27).
Manual St-St files size #10 and #15 were used to provide a manual glide path as recommended by the manufacturer before using rotary files, providing a pathway in the root canal to the full working length, to decrease stresses and fatigue on rotary file preventing file separation inside the canal and reduce amount of canal transportation which might occur during instrumentation (28-32).
Irrigation for all specimens during root canal preparation was done by using of 5% of NaOCl to remove all debris during root canal instrumentaion, facilate insertion of rotary files with no stress and to provide clean root canal walls. Then final rinse was done using 17% EDTA solution to remove all smear layer which found during instrumentation which might cause more force on rotary file causing canal transportaion, this protocol was aggreged with **Nazari Moghadam et al. (33)**. Moreover, **Ahmed et al. (34)** reported in their study that canal transportation might occur due to the physical properties of rotary files or the type of irrigation used during root canal prepartion, which might cause change in micro hardness of dentin, softening and deminerlization of dentin, that might compromise the preservation of the natural shape of the canal which could lead to canal transportation.
In the present study, CBCT scanning was the method for choice used to assess canal transportation and centering ability, which is the best widely available and accurate method for endodontic uses, giving more accurate findings in the evaluation of root canal transportation for clinical uses. A CBCT imaging system generates images that are geometrically accurate and distortion-free in all plane measures. In some studies, CBCT imaging has also been used as a measuring tool to evaluate the effectiveness of various root canal preparation and instrumentation techniques by **Kumar et al. (35) and Kiran et al. (36)**. Due to its accurate three-dimensional examination of root canal morphology, CBCT imaging is the most

reliable technology. Because CBCT's quality is well-established, it is used as a standard approach for comparing alternative file systems for canal transportation and centering ability.

The Null hypothesis of the present study was that there was no significant difference in the canal transportation and centering ability between the three Ni-Ti rotary file systems in the mesiobuccal canals of mandibular molars.

In the present study, TruNatomy rotary file showed the highest canal transportaion at three and six mm levels in comparison with the others rotary files. EdgeFile X-7 showed the lowest canal transportaion at three and six mm levels. At nine mm level, XP-endo shaper showed less canal transportaion and EdgeFile X-7 show higher canal transportation, However, no significance difference was found between the three rotary files at the three levels of root canal three, six and nine mm levels.

Regarding canal centering ability, At three and six mm levels EdgeFile X-7 showed better canal centering ability while TruNatomy files showed less canal centering ability. While at nine mm level TruNatomy files showed better canal centering ability while EdgeFile X-7 file showed less canal centering ability, However, no significance difference was found between the three rotary files at the three levels of root canal three, six and nine mm levels.

These results were aggreged with a study done by **Kabil et al. (37)** showing no significance difference between XP-endo shaper and TruNatomy at all root canal levels for canal transportation and centring ability. Moreover, our results were in line with **Pérez Morales et al. (38)** showing no significance difference between TruNatomy files and XP-endo shaper rotary files including apical transportation and canal centring ability.

Many possibilities explanation might support our result, the EdgeFile X-7 is a heat-treated rotary file made of an annealed heat-treated Ni-Ti files brand called Fire Wire (9, 10). These rotary files are more flexible due to the thermal process than standard Ni-Ti alloy-made rotary files, which also have better torque strength, canal tracking, and centering ability. EdgeFile X-7 are built of controlled memory wire, which gives rotary files with control memory features. In compared to other rotary files, all of these qualities provide less canal transportation and improved centering ability (11).

While the XP-endo shaper rotary file performed less well in terms of canal centering than the EdgeFile X-7, this could be attributed to the file's snake shape, which, when paired with continuous rotation at extremely high speeds (800-1000 rpm) and little torque, the file may diverge out of the root curvature during instrumentation. The XP-endo shaper's divergence from the root canal's centre might be linked at the tip with six cutting edges known as booster tips, which enable it to start preparation after a glide path of at least ISO 15, and then extend its working field from ISO 15 to ISO 30 (12).

Finally, the TruNatomy file generated minimal apical transportation and greater canal centering ability with no significant differences from the other rotary files, despite the fact that the apical size of the instrument; between 25 and 30, was not the same for the other groups. This is due to the rotary file's unusually slender form, which is attributable to the fact that the TruNatomy Ni-Ti wire is 0.8 mm in diameter rather than the 1.2 mm utilised by other rotary Ni-Ti file systems (13). The TruNatomy file system has basic geometric design which is a unique parallelogram form with an off-centered design which created by using a specific Ni-Ti wire that has been heat treated well to increase its flexibility. TruNatomy has a low risk of developing procedural errors such as canal transportation (14).

On the opposite side, our results were in contrast to **Werdina and Bahnam (39)** where EdgeFiles X-7 caused better canal centering ability in comparison with XP-endo shaper rotary file with staistically significance difference between rotary files. This difference might be due to use of simulated root canals in resin block with different angle of curvature, instead of natural root canals, also using of the EdgeFile X-7 at low speed 300 rpm and low torque at 2 Ncm.

Relevant to this present study, many factors influence canal transportaion and canal centering abilty where flexibilty ,degree of taper , speed and heat treated rotary files play important role preserving root canal anatomy.

CONCLUSIONS

Within the limitations of this study, it was concluded that:

- All tested rotary files result in canal transportation.
- All the three rotary systems were proved to instrument root canals with low canal transportation and good centering ability.
- EdgeFile X-7 produced better root canal instrumentation with a less degree of canal transportation and better canal centering ability than XP-endo shaper and TruNatomy files.

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