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Research Article

Assessment of the Cleaning Ability of A Novel Adaptive Core Rotary Instrument XP Shaper Versus one Shape Rotary System in Extracted Human Permanent Mandibular Molars: A Randomized *In vitro* Study

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Abstract

Objective: The purpose of the present *In vitro* study was to evaluate the amount of touched canal walls of the XP Shaper single file system as compared to One Shape single file system.

Methods: In this study, 16 human permanent mandibular first molars with single oval canaled distal roots were selected, then randomly and equally divided into 2 groups: Group 1 (XPS) and Group 2 (OS). The molars distal halves were separated, then mounted into epoxy resin blocks which were sectioned using ISOMET sectioning saw. The root sections were imaged with a stereomicroscope before and after instrumentation. Pre- and post-instrumentation scans were superimposed and evaluated using AutoCAD analytical software.

Results: The amount of touched canal walls results showed a statistically significant difference between Group 1 (XPS) and Group 2 (OS) in the coronal, middle and apical thirds ($p<0.001$). Likewise, the total amount of touched canal walls was significantly higher in Group 1 (XPS) than in Group 2 (OS) ($p<0.001$).

Conclusion: XP Shaper seems to be superior to One Shape rotary file in addressing the 3-dimensional structure of the root canal space of oval canals.

Keywords: Oval Canals; XP Shaper; One Shape; Amount Of Touched Canal Walls; Autocadl; Stereomicroscope

Introduction

The success of root canal treatment process relies primarily on achieving proper cleaning, shaping and sealing of the root canal system. This target can be reached through adequate chemo-mechanical preparation together with promoting maximum conservation of the root structure and respecting the original canal anatomy [1].

However, in many instances, the root canal space possesses an irregular oval shape cross-section, resulting in a difficulty in addressing the three dimensional space of the root canal. Such difficulty arises from the fact that rotary instrumentation usually carves a round cross-sectional shape, leaving behind untouched recesses in the extremities of the largest diameter of the oval canal [2]. This problem remains a major limitation during root canal instrumentation and, despite all the improvements intending to increase the flexibility of the current rotary files used nowadays, recent studies revealed that up to 80% of the canal walls may remain untouched after instrumentation. The incidence of oval-shaped canals was reported to be high in mandibular incisors, maxillary second premolars, and the distal root of mandibular molars [3].

In the last decade, advances in NiTi instruments and their kinematics allowed shaping of the root canals with single-file systems operated in rotary or reciprocating motion. The idea behind using a single file for instrumentation is to achieve faster mechanical preparation with reduced number of instruments inside the canal [4].

One Shape (Micro Méga, Besançon, France) has been introduced to the market as a single-file system rotary file. The One Shape file is made of conventional NiTi alloys, has a tip size of ISO #25 and 0.06 constant taper throughout the shaft and is used in continuous rotation. In 2016, a novel snake-shaped endodontic rotary instrument, the XP Shaper (FKG, La Chaux-de-Fonds, Switzerland), was introduced. It is manufactured from a MaxWire alloy with a tip size of ISO #27 and a 0.01 taper across the length of the instrument. According to the manufacturer, XP Shaper represents a new generation of rotary instruments that allows the file to adapt better to the three-dimensional structure of the root canal morphology [5].

To date, there are few data regarding the cleaning ability of the XP Shaper single-file system. Thus, this study was conducted to investigate the amount of canal walls touched after mechanical instrumentation with XP Shaper in oval shaped canals compared to One Shape rotary single file system.

Materials and Methods

Sample size

Based on a previous study by Azim., *et al*. 2017 [5] the difference in average percentage of untouched canal wall between the 2 groups is 17% ± 11%. Using power 80% and 5% significance level we needed to study 8 in each group. Sample size calculation was achieved using PS: Power and Sample Size Calculation software Version 3.1.2 (Vanderbilt University, Nashville, Tennessee, USA).

Specimen selection and preparation

A total of 16 extracted human permanent first mandibular molars, extracted for periodontal reasons, were collected from the department of Oral and Maxillo-facial surgery, Faculty of Dentistry, Cairo University. The teeth were disinfected in 5% sodium hypochlorite for 10 minutes, scaled using a hand scaler to remove any soft or hard deposits and stored in saline at room temperature until usage. The selected teeth fulfilled the following criteria:

- Mature teeth with complete root formation.
- No radiographic evidence of root calcification, internal or external resorption, fracture or caries.
- The distal root contained a single, patent, oval canal.
- The bucco-lingual to mesio-distal ratio in the coronal and middle sections ranged from 1.5 to 4.

The distal half of each molar was separated, followed by flattening of its coronal portion using a low-speed diamond cutting disk under copious irrigation, to standardize tooth length measurement at 16 mm. Then, a #10 K file was used to check the patency of the distal canals. Each root tip was sealed with a small ball of wax to prevent penetration of resin into the apical foramen. A custom-made brass mold was constructed for embedding of teeth in resin blocks. The mold consisted of three main parts; an interlocking floor and two L-shaped side walls with square cross sectional shape internal index. Figure 1 Each distal half was immersed in the resin till the level of the cemento-enamel junction using a parallelometer. After epoxy resin polymerization, all the blocks were marked, on their mesial surfaces, with a 0.5 indelible ink red marker at 9, 6, 3 mm from the apex, representing the coronal, middle and apical levels respectively, as reference for sectioning. Each block was sectioned using ISOMETTM precision sectioning saw with a blade thickness of 0.5 mm. Sectioning was done 0.5 mm coronal to each of the three marked levels and with blade being perpendicular to the long axis of the root in the block. Figure 2 A fourth cut was done at 0 point (root apex), to ensure that all of the three specimens had equal thicknesses. Each section was marked with a letter (C, M and A) on its coronal aspect to identify the coronal, middle and apical sections, respectively figure 3.

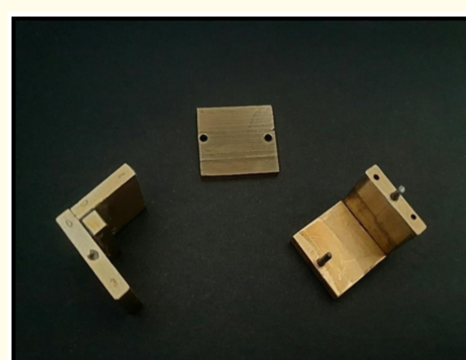

Figure 1: The mold consisted of three main parts; an interlocking floor and two L-shaped side walls with square cross sectional shape internal index.

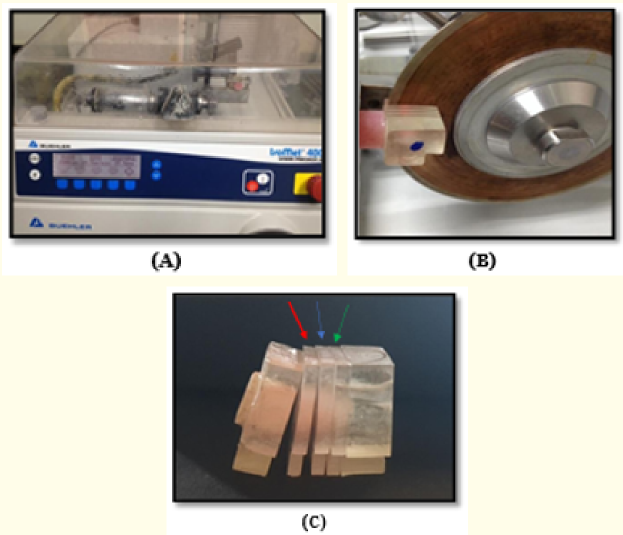

Figure 2: (A) Photograph showing ISOMETTM precision sectioning saw, (B) Sectioning was done 0.5 mm coronal to each of the three marked levels and with blade being perpendicular to the long axis of the root in the block, (C) A photograph showing the sectioned resin block; the red, blue and green arrows indicate the coronal, middle and apical sections respectively.

Figure 3: A photograph showing the resin sections of the root thirds marked with letters and numbers: A) Coronal third, B) Middle third, C) Apical third.

Pre-instrumentation imaging

A stereo microscope was used to magnify and photograph the coronal aspect of each of the three sections (coronal, middle and apical). The magnification for all samples was 16x. To allow a clear identification of the root canal outline, NaOCl (1%) was applied carefully by using a brush on each section until the root canal outline was clearly visible. Each sample was photographed from its coronal surface in a reproducible manner. Both pre and post-instrumentation images of the coronal, middle and apical thirds were captured JPG and organized in specific folders according to the group name and sample number.

Root canal instrumentation

Resin sections were reassembled in the mold for mechanical preparation. For both groups, all instrumentation procedures occurred in a warm water bath at 37°C. Another warm water bath was used to keep the irritant solution and the files at 37°C throughout the experiment. The working length determination was set to be 1 mm short of the root apex. Further 1.5 mm was subtracted to compensate for the lost thickness during sectioning. So, the final working length was set at 13.5 mm. The samples were randomly divided into 2 equal groups (n = 8 canals per group) and mechanically prepared as follows:

- **Group 1:** XP Shaper (XPS) (ISO #27, 1% taper): Instrumentation was performed using the instrument in continuous rotation with a 16:1 contra-angle at 800 rpm speed and 1 N.cm torque.
- **Group 2:** One Shape (OS) (ISO #25, 6% taper): Instrumentation was performed using the instrument in continuous rotation with a 16:1 contra-angle at 400 rpm speed and 2.5 N.cm torque.

For both groups, canal irrigation was done with 3 ml of warm, freshly prepared 2.5% NaOCl, before each file insertion inside the canal, using a disposable plastic syringe with 30G end vented needle. The flutes of the instrument were cleaned after three in-and-out pecking motions using NaOCl soaked sponge. Once the instrument reached the working length, a light brushing motion was applied toward the buccal and lingual recesses. Finally, the canal was irrigated with 5 ml of saline as a final rinse. Each instrument of XP Shaper or One Shape was used to prepare four canals only, then discarded. All instrumentation procedures were performed using the X-Smart plus endodontic motor according to manufacturer's instructions.

Post instrumentation imaging

After instrumentation, sections of each root canal were dissembled and photographed under the same conditions as for the pre-instrumentation images. Using PC software AutoCAD 2019, the pre and post- instrumentation outlines of the root canal were traced followed by superimposing of the pre- and post- instrumentation photographs in order to detect the amount of touched canal walls. The prepared outline was traced in a red color to differentiate it from the initial canal outline which was traced in a white color. By the aid of AutoCAD software, the following was measured:

- Length of the original root canal outline, (Lorig).
- The length of the original root canal outline that wasn't prepared, represented by contact (Lunprep) between the pre- and post-prepared outline figure 4.

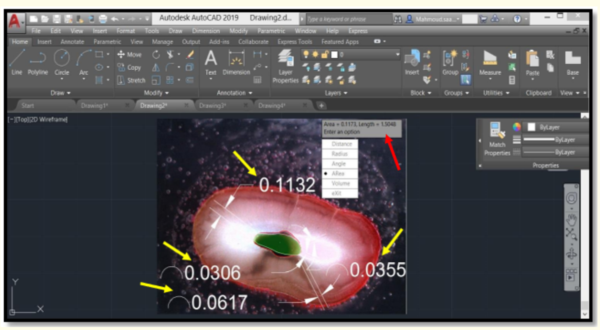

Figure 4: Length of the original root canal outline "Lorig" (red arrow), the length of the original root canal outline that wasn't prepared, represented by contact between the pre- and post-prepared outline "Lunprep" (yellow arrows).

The ratios of unprepared to the original canal outline Lunprep/ Lorig were calculated. A value of Lunprep/ Lorig = 1 (100%) indicated no dentin removal in this root canal section; a value of Lunprep/ Lorig = 0 indicated that dentin removal took place in all root canal walls. The percentage of touched canal walls could be calculated by the following formula: Lorig-Lunprep Lorig X 100.6

Statistical analysis

Data was analyzed using IBM SPSS advanced statistics (Statistical Package for Social Sciences), version 21 (SPSS Inc., Chicago, IL). Numerical data was described as mean and standard deviation. Data was explored for normality using Kolmogrov-Smirnov test and Shapiro-Wilk test. For parametric data; Independent Samples t-Test was used to compare between two groups in non-related samples, while Repeated measures ANOVA was used to compare between more than two groups in non-related samples. A p-value less than or equal to 0.05 was considered statistically significant. All tests were two tailed.

Results

The mean and standard deviation of the percentage of touched canal walls are presented in (Table 1 and 2). The t test showed a statistically significant difference in the percentage of touched surfaces between both groups (P < .001). The XP Shaper performed considerably better at all 3 locations (apical, middle, and coronal) with uniformly more touched surfaces (P < .001). Repeated measures ANOVA revealed statistically significant differences among root levels in both groups, with the highest mean touched canal walls values being apically and the lowest mean values coronally (P < 0.001).

System	Coronal		Middle		Apical		p-value
	Mean	SD	Mean	SD	Mean	SD	
XPS	69.11	4.68	75.03	3.99	86.49	3.93	<0.001*
OS	40.59	5.73	58.85	5.02	68.19	6.57	<0.001*
p-value	<0.001*		<0.001*		<0.001*		

Table 1: Mean, standard deviation (SD) and results of Independent Samples t-Test and Repeated measures ANOVA for comparison between amounts of touched canal walls values (%) at different root levels after using the two systems.

*; significant (p<0.05) ns; non-significant (p>0.05)

System	Mean	SD
XPS	76.88	8.40
OS	55.88	12.96
p-value	<0.001*	

Table 2: Overall mean, standard deviation (SD) and results of Independent Samples t-test for comparison between amounts of touched canal walls values (%) after using the two systems.

Discussion

The ultimate goal of endodontic treatment is to eradicate bacterial populations from inside the canal or, at least, reduce their count to the levels that would promote healing of peri-radicular tissues. However, the extreme diversity in the anatomy of the root canal system adversely affects the efficacy of the chemo-mechanical preparation creating a challenge in achieving the fore-mentioned target of endodontic procedures [7].

The present study was conducted to compare the amount of touched canal walls, as well as the canal transportation and the centering ability of the XP Shaper and One Shape rotary files, in extracted permanent first mandibular molars.

Our study was designated to be a comparative *In vitro* study to ensure control of the variables and uniformity of the results. To simulate clinical situations and allow a realistic assessment of the instruments' performance, extracted permanent first mandibular molars with single oval canal in the distal root were incorporated in the study [8]. Where, numerous studies stated that buccal and lingual extensions of oval shaped canals were left unprepared following hand and rotary instrumentation, which could harbor remnants of necrotic pulp tissue, bacterial biofilms and dentin debris [8-10].

To ensure standardization of all the samples, the distal halves of the molars were separated and flattened to a pre-determined length of 16 mm. Each root tip was sealed with a small ball of wax to prevent the flow of resin through the apical foramen, and inside the canal, thus impairing its patency.

The custom-made brass mold represented a modification of the model proposed by Bramante for comparing the root canal anatomy before and after canal instrumentation [11]. It was fabricated for embedding of the samples in resin blocks, and to allow easy reassembling of the sectioned specimens for chemo-mechanical preparation, following the pre-instrumentation scanning procedure. Using a parallel meter to immerse each sample in epoxy resin aimed to ensure parallelism between the sample and the mold long axes until setting.

The resin blocks were sectioned using ISOMETTM precision sectioning saw; due to its ability to cut with minimal specimen deformation and low kerf loss [12]. Since the sectioning saw had a blade thickness of 0.5 mm, cutting was initiated 0.5 mm coronal to the three marked levels; to make sure that the sections produced represented the pre-determined root levels precisely (9,6 and 3 mm from the apex). A fourth cut in the resin block was made at 0 point (root apex), to guarantee that all of the three sections had equal thicknesses, which was deemed necessary for standardization of the stereomicroscope imaging parameters.

A stereomicroscope was used to magnify and photograph the root sections coronal aspect; as it provided images with high quality [13]. The scanning process was done under the same conditions (i.e. magnification and focal length), before and after canal instrumentation, to ensure standardization. Setting the magnification at 16x promoted a clear visualization of root canal borders, which facilitated the canal outline tracing procedure during image analysis.

All instrumentation procedures were performed in a warm water bath (37°C) to mimic clinical conditions; as it was demonstrated that heat-treated instruments, such as XP Shaper, can change from the martensitic to the austenitic phase when used in the oral cavity [5]. Moreover, simulation of body temperature was considered of prime importance; since it was estimated that temperature changes would affect the XP Shaper expansion properties. Though One Shape rotary system wouldn't be affected by the temperature changes, it was applied in the same condition for standardization. Both rotary instruments were used with an in-and-out pecking motion till the working length, then a light brushing motion was applied toward the buccal and lingual recesses to increase the file contact with canal walls.

The irrigant of choice during mechanical procedures was 2.5% Sodium hypochlorite (NaOCl); due to its tissue dissolving capabilities, antibacterial property and lubricant action [14,15]. Such concentration was found to balance between the desired anti-bacterial effect and low cytotoxicity, which is the reason why it is the most commonly used NaOCl concentration in clinical practice [16].

The AutoCAD software is a Computer Aided Design/Drafting (CAD) program developed by Autodesk and is used by architects to design buildings and structures as it provides accurate measurements [17]. In the present study, the AutoCAD 2019 program allowed tracing of the root canal outline with high precision. Moreover, the software enabled accurate superimposing and manipulating of the pre and post instrumentation images. This helped the evaluator to easily detect canal areas that had been touched by the rotary instrument, which ensured reliable calculations while minimizing bias. A number of researchers had used AutoCAD to study different parameters such as measuring root canal curvature [18], calculating the amount of touched canal walls [6], determining instrument's cross sectional measurements [19], assessing instruments shaping ability [20], and evaluating the efficacy of different instruments in removing gutta-percha and sealer during root canal retreatment [21].

Regarding the results of this study, there was a statistically significantly more touched canal walls in the XP Shaper group (76.88%) compared to the One Shape group (55.88%) ($P < 0.001$). This was observed at all canal levels (coronal, middle and apical). Such findings highlight the unique expansion properties of the Max Wire alloy that constitute the XP Shaper. Once subjected to body temperature, the alloy undergoes a phase transformation, shifting from the martensitic to the austenitic phase; which allows the file to expand beyond its core size and address more canal walls, hence, the name "core adaptive file" [5]. On the other hand, the percentage of prepared canal walls in One Shape group seems to be consistent with previous reports on "non-adaptive core" rotary files; a term used to describe those instruments which tend to sculpt the canal into a rounded uniform shape without addressing the individual variations of each canal [5,8,22].

Up till now, the data regarding the cleaning ability of XP Shaper are scarce. However, one may argue that the current results can't be directly compared to earlier studies evaluating the amount of touched canal walls by XP Shaper; due to different methodological approach. However, similar results were reported by Azim., *et al.* who found a statistically significant difference between XP Shaper and another "non- adaptive core" file.5 On the contrary, Lacerda., *et al.* revealed comparable cleaning and shaping effects, through the whole canal length, on comparing XP Shaper to Self-adjusting file and TRUS hape [3].

It is noteworthy that both groups showed statistically significant differences among root levels ($P < 0.001$) with the highest mean touched canal walls values being apically and the lowest mean values coronally. This can be attributed to the fact that the long diameter of oval root canals generally decreases as the canal progresses apically, resulting in a less oval cross section and allowing more canal walls to be touched by the rotary instrument [23].

Conclusions

Within the limitations of this study, it could be concluded that neither instruments were able to completely prepare oval-shaped root canals. However, the XP Shaper seems to be superior to One Shape rotary file in addressing the 3-dimensional structure of the root canal space of oval canals by touching more canal walls.

Conflict of Interest

The authors deny any conflicts of interest in this study.

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