Comparative Study of The Amount of Apically Extrusion Of Debris During Root Canal Preparation Using Wave One™, Trushape 3D™, Hyflex™ CM and One Shape™ Instrumentation Systems (An In Vitro Study)

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ABSTRACT

Background: Many types of instruments and techniques are used in the instrumentation of the root canal system. These instruments and techniques may extrude debris beyond the apical foramen and may cause post-instrumentation complications. The aim of this study was to evaluate the amount of apically extruded debris resulted by using 4 types of nickel-titanium instruments (WaveOne, TRUShape 3D conforming files, Hyflex CM, and One Shape files) during endodontic instrumentation.

Materials and methods: Forty freshly extracted human mandibular second premolar with straight canals and a single apex were collected for this study. All teeth were cut to similar lengths. Pre-weighted glass vials were used as collecting containers. Samples were randomly divided into four groups with 10 samples in each group: **Group A** instrumentation by WaveOne reciprocating file, **Group B** instrumentation by TRUShape 3D rotating files, **Group C** instrumentation by Hyflex CM rotating files and **Group D** instrumentation by One Shape rotating file. A total volume of 7 ml of sodium hypochlorite was used for irrigation in each sample. Apical patency confirmed and maintained by a size #15 K-File. All canals were instrumented up to a size #25. After completion of endodontic instrumentation, vials were then stored in an incubator for 5 days at 68° C for dryness. Then vials are weighted again, and the pre-weight subtracted from the post-weight, the weight difference resembled the amount of apically extruded debris from the apical foramen during root canal instrumentation. Data obtained were statistically analysed by using ANOVA and LSD tests.

Results: The results showed that the Hyflex CM Group (C) has statistical significant lowest apically extruded debris as compared to other groups of this study (P ≤0.05), while the TRUShape Group (B) has statistical significant lowest apically extruded debris as compared to One Shape Group (D) and WaveOne Group (A), while the WaveOne Group (A) showed the highest value of apically extruded debris (p ≤0.01). The result showed that all groups resulted in apical extrusion of debris.

Significance: Although all systems caused apical extrusion of debris and irrigant, continuous rotary instrumentation was associated with less extrusion as compared with the use of reciprocating file system.

Key words: debris extrusion, rotary instrumentation, NiTi instruments. **(J Bagh Coll Dentistry 2017; 29(1):1-8)**

INTRODUCTION

The main objectives of root canal instrumentation include a complete disinfection and debridement of the root canal system, in addition, to create a proper shape to attain a complete three-dimensional obturation. A thorough preparing of the apical region has long been considered a crucial asset in the cleaning and shaping stage [(1)].

In asymptomatic chronic periradicular lesion, there is a balance between the host defence and the infected canal microbiota. If this balance is disrupted by the extrusion of bacteria apically during instrumentation, an acute inflammatory response will occur in order to re-gain the equilibrium, which in turn could result in postoperative complications like flare-up, which is described by pain, swelling, or both [(2)].

During the instrumentation procedure, debris such as necrotic pulp tissue, dentinal shavings, irrigants, bacteria and their by-products may be pushed beyond the apex onto the periradicular tissues which could cause and inflammatory response, postoperative pain and possible delayed healing [(3)].

Cleaning and shaping of the root canal system is carried out mainly by step-back or crown-down techniques. Hand and rotary instruments are used with either of these techniques. Advanced instrument designs such as variable tapers, radial lands, different flute depths, cross-sections, and noncutting tips and the use of different operational techniques have been developed for the improvement of working safety, create a greater flare within preparation, shorten working time, and to provide a smoother and cleaner preparation to receive the final obturation [(27)].

WaveOne NiTi file system is a reciprocating file claimed to complete the root canal instrumentation with only one file using a special reciprocating motion. The files are made of an alloy called M-Wire which is created by an innovative thermal treatment and claimed to have superior

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flexibility and cyclic fatigue resistance. The files are available in three sizes of 21/.06, 25/08, and 40/08 that are used in a special automated device [5].

TRUShape 3D conforming files is a recent rotating system that have a unique S-shaped design that is claimed to allow the file to conform to irregular and larger shapes than the files original size, the file compresses in small areas and springs in wide areas and creates an envelope of motion inside the root canal, the system comes in four sizes 20/.06, 25/.06, 30/.06, and 40/.06 [6].

The One Shape file by Micro Mega (Besanc on, France) is a single-file system, used in continuous clockwise rotation. These instruments have an innovative design with three different cross-sectional areas over the entire length of the working part and have a variable pitch and a noncutting safety tip [7].

The HyFlex CM multiple-file system (Coltene Whaledent, Cuyahoga Falls, OH, USA) was developed for use in continuous rotation and is composed of a modified NiTi alloy (52 Ni wt% versus 54.5–57 Ni wt% in conventional NiTi alloys). This alloy undergoes Controlled Memory (CM) thermomechanical surface treatment, which increases the fatigue resistance by 150% and 390% compared with M-Wire and non-surface treated conventional NiTi alloy, respectively. Due to the lack of shape memory, this system enables visual functionality verification. The shape and strength of files with straightened spirals can be restored during autoclaving and reused, but files that do not return to their original shape should be discarded [8].

The amount of debris may vary depending upon the instrumentation method, file size and file type. Instrumentation should be performed in a manner that minimizes the amount of debris extruded into periapical tissues [9].

Although cleaning and shaping of the root canal are accomplished by instrumentation, it is essential that this should be accompanied by copious irrigation. This procedure not only “flushes out” pulpal debris and dentin chips, but also helps to lubricate endodontic instruments and facilitates their cutting action [10].

The first attempt to quantify the amount of apically extruded debris has been made by **Vande Visse and Brilliant** in **1975** [4].

As AED generates an acute inflammatory reaction in the periapical tissues, it is considered as an important parameter to assess the efficacy of an instrumentation technique or instrument design during root canal preparation. Also no studies have been conducted to determine the amount of debris extrusion resulting from the use of the new rotary instrument, TRUShape 3D. The aim of this study was to compare the amount of AED during root canal preparation using WaveOne™ reciprocating file compared with the rotary TRUShape™ 3D conforming files, One Shape™ and HyFlex™ CM files.

MATERIALS AND METHODS

Sample selection

Forty freshly extracted human mandibular second premolar teeth were collected from different specialized dental centers (teeth were extracted for orthodontic reasons and the patients age ranged from 20-30 years old). Immediately after extraction, bone, calculus, stains and soft tissues on the tooth surface were removed manually with cumine scaler. Each tooth was then radiographed bucco-lingually and proximally to confirm single canal and single apical foramen. teeth with calcification, open apices, severely curved canals, internal and external resorption were excluded from this study. All teeth were decoronated using a diamond disk under copious water to a length of 15 mm to achieve similar teeth lengths and a flat reference point [11].

Teeth were then stored in a 10% formalin solution for disinfection until the time of use and then stored in normal saline during the experiments**.** the external surface of the roots was covered with two layers of nail polish except for the last apical 1 mm **Fig. 1**

Figure 1: measurement of the length of the root with digital caliber.

Method of sample fixation and debris collection

Each glass vial was weighted without the rubber stopper with an electrical balance with a precision of 0.0001 before its use, the weight was recorded after having three identical readings. A rubber cap of a glass vial was adjusted for use by making a hole in the center and then a tooth was pushed through this hole up to the cementoenamel junction and then the tooth-cap complex was fitted on the glass vial, the apical part of the tooth was suspended within the vial which acted as a collecting container for extruded debris and irrigants. A bent gauge 25 needle was forced through the rubber stopper alongside the tooth surface to act as a draining cannula and to equalize the pressure between the inside and outside of the vial [12]. **Fig. 2**

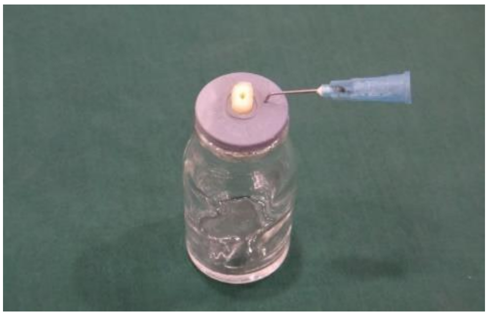

Figure 2: Tooth-rubber cap assembly fitted on glass vial with needle attachment.

Sample preparation

Endodontic access cavities were performed with Endo access bur and a high speed handpiece under copious amount of water, pulp tissues were extirpated with a barbed broach, and apical patency was confirmed with a size #15 K-File (if the file passes freely through the foramen, then the specimen will be discarded). Working length determination was made by subtracting 1 mm from the length of the 15mm long root to standardize the WL for all specimens at a 14mm.

Sample grouping

The specimens were randomly divided into four groups (each group containing 10 samples) according to the type of instrumentation systems used:

- **Group A:** Instrumentation with WaveOne reciprocating files.
- **Group B:** Instrumentation with TRUShape 3D conforming files.
- **Group C:** Instrumentation with Hyflex CM files.
- **Group D:** Instrumentation with one shape file.

Preparation of canals

The sequences used in this study were done according to the manufacturer's instructions for each system. All canals prepared to MAF # 25.

Disposable side-vented navi tip needle with 30-gauge was used for irrigation in this study. The needle tip was inserted passively and never allowed to bind as the irrigant was being slowly deposited into the canal and never allowed to reach more than 2mm from the WL [13].

For standardization purposes the irrigation protocol was done using a total volume of 7-mL of sodium hypochlorite with a final flush of 3-mL. Each file was used for 3 canals and then discarded [13].

After completion of each canal instrumentation, the external surface of the root was irrigated with 2-mL of normal saline into the glass vial to collect any adhering debris. **Fig. 3**

Figure 3: washing the apex with normal saline

Group A: instrumentation with WaveOne single file in a reciprocation motion

Canal preparation performed by the WaveOne file according to the manufacturer's instructions. The WaveOne program was chosen on the X-smart Plus Endodontic engine. The primary file was inserted and the rubber stopper at full working length. Initial shaping was done with a gentle inward pecking motion, with short 2-3 mm amplitude strokes, to passively advance the file until it does not easily progress anymore. The file was then withdrawn, cleaned, then the canal was irrigated and checked for patency. The WaveOne file was then re-inserted and the procedure is repeated until full working length is reached. Final irrigation and patency checking was done.

Group B: rotary instrumentation with TRUShape 3D conforming files

Canal preparation performed by the TruShape 3D conforming file according to the manufacturer's instructions in the following sequence:

The canal was flooded with irrigant then the first TruShape file 20/0.06 with a yellow ring was introduced into the canal by using the X-Smart plus endodontic engine at a speed of 300 rpm and torque at 3 N/cm with a gentle 2-5 mm in-and-out motion to shape the middle third, with a 2-3 mm amplitude in-and-out motion towards the apex. Abrupt pecking motions were avoided. File was then withdrawn and its flutes were cleaned and the canal was irrigated and canal patency re-confirmed with a #15 K-File. The procedure is then repeated until working length was reached. The next file 25/0.06 with a red ring was then used in the same movement fashion until working length was reached then withdrawn once it has reached working length. Canal was irrigated thoroughly and patency was re-confirmed.

Group C: rotary instrumentation with Hyflex CM files

Canal preparation performed by the Hyflex CM files according to the manufacturer's instructions. Speed of rotation was set to 500 rpm and torque at 2.5 N/cm on the endodontic engine. The orifice opener 25/0.08 was used first for the coronal preparation in a smooth in-and-out tipping motion. Then the 20/0.04 file used in the same motion to full working length for apical preparation. Then the

25/0.04 file was then used to full working length to finish apical preparation. Finally, the 20/0.06 file was used to full working length for the middle segment preparation.

After each file application the spirals of the file were inspected for straightening, the file was placed in hot water for about 10 seconds until it regains its original shape.

Group D: rotary instrumentation with One Shape file

Canal preparation performed by the One Shape files according to the manufacturer's instructions. G1 file 12/0.03 was introduced into the canal in a slow downward movements in a free progression and without pressure motion to working length at 250-400 rpm and max torque of 1.2 N/cm. Canal is then irrigated and G2 file 17/0.03 used to working length in the same fashion. Canal was irrigated and patency checked with a size #15 K-File. One shape file was then used at 400 rpm and 2.5 N/cm with in-and-out movement for about 2-3 mm without pressure, then the file is withdrawn and cleaned and canal irrigated and patency checked with #15 K-File. This is repeated until working length is reached.

Sample incubation and re-weighting

After removing the tooth-cup assembly, the glass vials were then stored in an incubator at 68˚C for 5 days in order for water evaporation leaving only the extruded debris [14]. Then the vials were transmitted from the incubator to the electrical balance for re-weighting, the reading was recorded from three repeated readings.

The weight of debris of each sample was calculated from subtracting the values of Pre-weight from post-weight of the vial for each sample of all groups of this study.

Statistical analysis

ompared with group (D) One Shape ($P \leq 0.01$).

Descriptive statistics including: minimum, maximum, mean and standard deviation were calculated for the mean for the groups of this study by using Statistical Package for Social Science SPSS (version 13.0) for Windows (SPSS Inc., Chicago, IL, USA).

Inferential statistics: including:

1. One-way analysis of variance test (ANOVA) to find any statistically significant difference among the groups.
2. Least significant difference test (LSD) to find any significant difference between the groups.

RESULTS

The results of this study showed that all groups resulted in extrusion of debris with different values. The mean values (in mg), and SD of AED for all groups are shown in **Table (1)** and **Fig. 4**

Hyflex CM group (C) showed the lowest mean value of AED in comparison with other groups followed by TRUShape (B), One Shape (D), groups respectively, While the WaveOne group (A) had the highest mean value.

Analysis of variance (ANOVA) test was performed to identify the presence of any statistically significant difference among groups, **Table (2)**. ANOVA test showed a very high significant difference among groups ($p<0.05$).

The result of LSD test **Table (3)** showed that there was a significant difference between group (A) WaveOne and group (B) TRUShape ($P < 0.05$). Group (A) showed a very high significant difference ($P \leq 0.001$) as compared with group (C) Hyflex CM. and showed no significant difference as compared with group (D) One Shape ($P \geq 0.05$). While Group (B) TRUShape showed a significant difference as compared with group (C) Hyflex CM ($P < 0.05$). And showed no significant difference as compared with group (D) One Shape ($P \geq 0.05$). And Group (C) Hyflex CM show a high significant difference as

Table (1): The mean values of apically extruded debris (in mg) and SD for all groups.

Groups	N	Mean	SD
A	10	0.369	0.0568
B	10	0.315	0.0345
C	10	0.267	0.0609
D	10	0.337	0.0284

Table 2: ANOVA test for mean of apically extruded debris among groups.

	Sum of Squares (SS)	df	Mean Square (MF)	F-test	P-Value
Between Groups	.055	3	.018	8.200	0.000
Within Groups	.080	36	.002		
Total	.135	39			

Table 3: LSD test for multiple comparisons between groups.

Groups		Mean Difference (I-J)	P-value	Sig.
Group A	**Group B**	0.053*	0.016	*
	Group C	0.102*	0.000	**
	Group D	0.032	0.139	NS
Group B	**Group C**	0.048*	0.027	*
	Group D	-0.021	0.319	NS
Group C	**Group D**	-0.070*	0.002	**

$P \geq 0.05$ Non-Significant (NS) $P < 0.05$ Significant (S) *

$P \leq 0.01$ High Significant (HS) * *

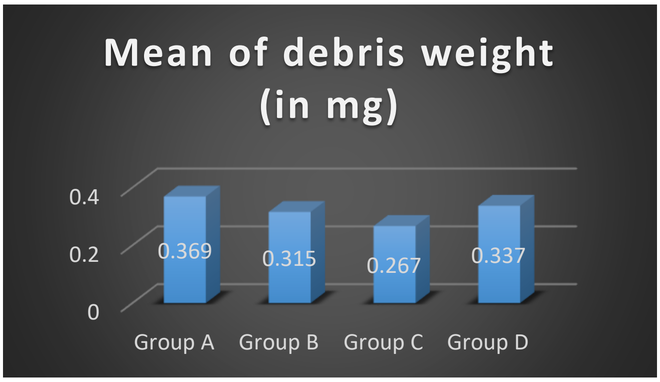

Figure 4: Mean values of apically extruded debris of all groups of this study.

DISCUSSION

The main objective of chemomechanical instrumentation is the total elimination of infected pulp tissue from the root canal, proper cleansing of the canal space is considered essential for success in endodontics. To achieve these objectives, pulpal remnants and debris must be removed from the root canal walls. Mechanical instrumentation establishes an adequate canal shape, allowing easy access of irrigating solutions to the entire canal space and adequate obturation (15).

Root canal instrumentation requires technical knowledge to be applied to the biological area, so as to obtain a well instrumented and disinfected canal without damage to its biological structure. Since the root canal includes the space that contains the pulpal organ, one of its ends is in the pulp chamber and the other corresponds to the apical foramina. Thus, instrumentation of root canals can cause extrusion of material through the foramen by virtue of the anatomy of the canal itself (16).

During root canal treatment, debris and irrigant may extrude from the apical foramen and cause post-instrumentation pain or flare-up. These debris mostly contain pulp tissue remnants, dentin chips, microorganisms, necrotic tissue, and root canal irrigants. When debris is pushed out of apical foramina, it will result in an Ag-Ab reaction. This reaction will generate an acute inflammatory reaction in the periapical tissues, and cause damage to the cell membrane resulting in prostaglandins release, bone resorption, amplification of the kinin system and ultimately pain for patient (17) (2).

Many studies have looked at various aspects of apically extruded debris and irrigants. The results have shown that preparation up to the apex, the diameter of apical patency, the amount of irrigant used, formation of a dentine plug, the use of step-back versus crown-down technique, and the use of conventional hand filing versus rotary motion, all have a correlation to the amount of extruded debris (18).

Irrigation or chemical debridement is accepted as being a necessary aid in the chemomechanical cleansing of the root canal as irrigation assists in debris removal. More debris are removed when greater quantities of irrigating solutions are used. Furthermore, the proximity of the irrigating needle to the apex plays an important role in removing the canal debris (19).

Beeson et al., (20) in 1998 reported that, when the instrumentation was performed to the apical foramen, significantly more debris was forced apically than when instrumentation was done 1 mm short.

The present study showed that WaveOne single file system has the maximum amount of apical debris and irrigant extrusion when compared to TRUShape, Hyflex CM, and One Shape rotary files, this might be due to the reciprocation movement in WaveOne system is formed by a wider cutting angle and smaller release angle. While rotating in the release angle the flutes will not remove debris but push them apically. Furthermore, the WaveOne file shows radial lands, and this feature can reduce the coronal debris removal capacity, enhancing apical debris extrusion.

Moreover, WaveOne file is quite big, rigid with an increased taper (0.08 taper) which is directed to reach the apex this result agrees with Webber J. et al., 2011. (21). Moreover, WaveOne files due to their reciprocating and in-and-out filing motion, may act as a piston, extruding more debris and irrigant than rotary instrumentation techniques. While the file with continuous rotation act like a screw conveyor improving transportation of dentin chips and debris coronally (11). Also this result agrees with many studies. Gianluca et al., (22) in 2013 evaluated the incidence of postoperative pain when WaveOne, TF15, and TF Adaptive systems were used for chemomechanical preparation for root canals. They measured that the incidence of postoperative pain was significantly higher with the WaveOne single file reciprocating system. Surakanti JR et al., (5) in 2014 made a Comparative evaluation of apically extruded debris during root canal preparation using WaveOne, ProTaper, Hyflex and rotary systems. And showed that the Hyflex system was associated with less amount of apically extruded debris compared to ProTaper universal and WaveOne. Nevares G et al., (23) in 2015 compared the amount of apically extruded debris between WaveOne, Reciproc and Hyflex CM. and reported that Hyflex CM system had the lowest mean of apically extruded debris followed by WaveOne and the Reciproc files.

Singh A et al., (24) in 2015 compared the amount of AED and between WaveOne, ProTaper hand and M Two files. WaveOne single file reciprocating system showed the maximum amount of apical debris and irrigant extruded when compared to ProTaper hand and M-two rotary systems.

The result of this study showed that the One Shape file showed less amount of AED than the WaveOne but more than the TRUShape and Hyflex CM files. One Shape file has three variable cross-sections along the length of the blade. Towards its tip, the file has a variable three-cutting-edge design. In the middle, the cross-section progressively changes from three to two cutting edges, and towards the shaft the blade has two cutting edges. The file has an aggressive cutting ability which removes a substantial amount of dentin in a relatively shorter period of time, but they are unable to displace the debris coronally and hence, enhance apical extrusion of debris (11). This result agrees with Nayak G et al., (25) in 2014 who made an evaluation of AED and irrigant using the One Shape, WaveOne and Reciproc single file systems. They reported that the One Shape rotating file showed the lowest amount of apically extruded debris and irrigant as compared to Reciproc and WaveOne reciprocating files.

The TRUShape system revealed an amount of apically extruded debris less than One Shape and WaveOne but more than Hyflex CM files. These files have a unique S shaped design which produces and envelope of motion that may help in the auguring of debris coronally. In addition, it acts as a spring, so in tight spaces the file compresses and in wide areas it springs to convey larger areas of the original file size. The file's lesser maximum flute diameter or 0.08 mm might be a factor in the extrusion of debris apically.

According to the results of this study, Hyflex system showed the least amount of AED comparing to other systems, this result is in agreement with Surakanti JR et al., 2014 (5) who showed that Hyflex CM system had the lowest mean of AED in their study.

Hyflex CM™ files have multiple cross-sectional designs, some instruments (.06/20, .04/30 and .04/40) have triangular cross section with three blades and three flutes, others (.04/20 and .04/25) have quadrangular cross section with four blades and four flutes. The cutting profile of each Hyflex CM™ file facilitates penetration in the canal and presents a root canal shape corresponding with the original anatomy (22). This system has a taper of 0.04 % which is less than all other systems which could be a cause of less extrusion apically because the amount of the cut dentine is less. Additionally, Capar et al. (2014) (26) found that during root canal instrumentation with the HyFlex CM system, the spirals unwound in 95% of the instruments (114/120 uses). And 80% of instruments were distorted. The lower extrusion rate in the Hyflex group could be related to this design modification, which could reduce the cutting efficiency and the amount of collected debris

CONCLUSIONS

Under the experimental conditions of this in vitro study, the following conclusions can be drawn:

The result showed that all groups resulted in apical extrusion of debris.

The Hyflex CM Group (C) showed the lowest amount of apically extruded debris compared to other groups, followed by TRUShape Group (B), One Shape Group (D) respectively.

WaveOne Group (A) showed the highest value of apically extruded debris.

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