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CUTTING EFFICIENCY AND CLEANING ABILITY OF THREE DIFFERENT NICKEL TITANIUM ROTARY SYSTEMS (AN IN VITRO STUDY)

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ABSTRACT

Purpose: the goal of this study is to assess the cutting efficiency and cleaning efficiency of Trunatomy, Hyflem CM & 2shape NiTi Rotary files.

Material and methods: A total of thirty human multirooted lower molars were obtained. The teeth were categorized into three groups (n=10) based on the rotary system used. Group 1 was prepared using Trunatomy rotary system, group 2 were prepared using Hyflex CM, and group 3 were prepared using 2shape rotary system. Cutting efficiency was evaluated using CBCT while cleaning ability was evaluated using stereomicrscope. The data was analyzed using Shapiro-Wilk test.

Results: No significant difference was seen among the three rotary files in canal volume change while a significant difference was seen among them in debris percentage where the minumum mean value in Trunatomy group.

Conclusion: the three rotary files showed comparable cutting efficiencies while Trunatomy files showed better cleaning ability than the other rotary systems.

KEYWORDS: Trunatomy, Hyflex CM, 2shape, CBCT, Steriomicroscope.

INTRODUCTION

The success of a root canal procedure relies on two primary factors: thorough cleaning and shaping. Proper cleaning is required to provide a good seal and prevent failure. Cutting efficiency is one of the fundamental qualities of (NiTi) endodontic instruments [1,2]. It is described as the ability to remove dentin from root canal walls in order to form a regular funnel-shaped channel, which simplifies the subsequent filling procedure [1,3].

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Endodontic files made of nickel titanium (NiTi) are effective for canal preparation. They can be used alone or in conjunction with stainless steel equipment to effectively prepare pulp canals while reducing working time.

A lot of new NiTi tools have been made in the last ten years thanks to improve design, physical characteristics, metallurgy, kinematics, and thermal treatment of NiTi alloy. As instruments are constantly being changed and made, more study needs to be done on how well they work so that clinicians can use evidence-based practice to make good decisions.

TruNatomy (TRN) is a newly introduced rotary file systems contains three shaping instruments in three different sizes with an off-centered parallelogram cross-section design. TruNatomy tools preserve structural dentine and tooth integrity thanks to their regressive tapers, thin design, and instrument shape. TwoShape is a file system made of T_wire Heat-treated with NiTi alloy to enhance flexibility and superior ability to navigate via curved canals. Hyflex CM system is made from a NiTi wire (CM Wire). They were found to have more flexibility,improved torsional strength, and fatigue resistance compared to conventional NiTi rotary instruments manufactured from superelastic wire.

Cutting efficiency and cleaning ability of 2shape and Trunatomy were not sufficiently assessed in the literature, Therefore it was thought that it would be value to determine the cutting efficiency and cleaning ability of Twoshape and Trunatomy in comparison to Hyflex CM .

MATERIALS AND METHODS

Thirty human permanent multi-rooted mandibular molars were obtained from the outpatient clinic of the oral surgery department at Ain Shams University's Faculty of Dentistry. The selected teeth were cleaned of calculus deposits using ultrasonic scalers and in 5.25 (NaOCl) for 15 min. to eliminate any type of soft tissue and organic matter. Thirty teeth were put in three arches of pink wax. All teeth's access cavities were prepared with a high-speed handpiece equipped with a round and tapered fissure bur. Teeth lengths were measured by inserting a K-file size 10 into the canal until the tip of the file could be seen from the apex. The working length was obtained by subtracting one millimetre from the tooth length. Following length determination, files #10 and #15 were used to guarantee canal patency and generate a glide route. Irrigation with 5 mL of 2.5% (NaOCl).

Thirty multirooted mandibular molars in their arches divided to three groups according to instrument :

Group A: preparation of the canal with TruNatomy rotary files (n=10). After adjusting the working length, canals were instrumented using TruNatomy rotary files (Orifice modifier: 20/.08,Glider:17/.02, Prime: 26/.04) using Endo motor (E-cube) (engine setting :500 Rpm & 1.5 N/CM). A pecking motion until the file reached the working length.

Group B: preparation of the canal with HyFlex rotary files (n=10). After adjusting the working length, canals were instrumented using Hyflex CM files using the Endomotor(engine setting :500 rpm and 2.5N/cm). 1st file used was Hyflex CM (25/ 0.08, 19 mm), 2nd Hyflex (CM 20/0.04, 25 mm), 3rd Hyflex CM (25/ 0.04, 25mm). A pecking motion was used until the file reached the working length.

Group C: preparation of the canal with 2Shape rotary files (n=10). After adjusting the working length, canals were instrumented using 2shape files using the Endomotor (engine setting :350 RPM, 2.5 N/cm). 1st file used was One Flare (25/ 0.09, 17 mm), One G (14/0.03, 25 mm), 3rd 2Shape TS1 Mini (25/ 0.04, 25mm). A pecking motion was used until reaching the working length

All Samples were subjected to two different evaluation methods:

Part I: Evaluation of the cutting efficiency using cone beam CT before and after instrumentation.

Part II: Evaluation of the cleaning ability using stereomicroscope. Each tooth was cut into 2 halves longitudinally, two parallel longitudinal grooves were made by low speed diamond disk on the out surface of the roots with out perforating the root canal,the roots split into halves with small chisel to prevent contamination of the canal. Each root canal was divided into three same segments (coronal, middle & apical) using calibrating ruler & pencil.

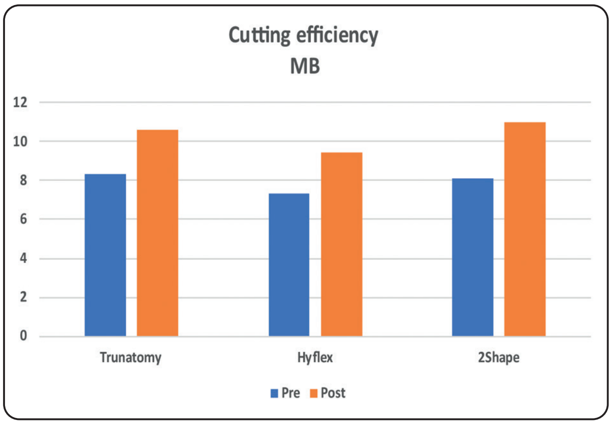

Fig. (1) Bar chart representing means of Canal volume before and after preparation

RESULTS

Effect of mechanical preparation on canal volume

Trunatomy group: The maximum mean value of canal volume in (Post) (10.58 ±0.88), the minimal mean value of canal volume in (Pre) (8.31±0.78). Significant difference was detected between (Pre) & (Post) where (*p*=0.010). (**Hyflex CM group**)The maximum mean value of canal volume in (Post) (9.54±0.75), the minimal mean value of canal volume in (Pre) (7.32±0.64). Significant difference was detected between (Pre) &(Post) (*p*=0.001). (**2Shape group**)The maximum mean value of canal volume was found in (Post) (10.99±0.86), the minimal mean value of canal volume was found in (Pre) (8.11±0.48). Significant difference was detected between (Pre) & (Post) (*p*=0.005).

Effect of file system on canal volume change:

The maximum mean value of canal volume change was detected in **(2Shape)** (36.65±9.71), followed by **(Hyflex CM)** (31.97±6.70), then **(Trunatomy)** (31.02±10.79). No significant difference was detected between **(Trunatomy), (Hyflex CM)** and **(2Shape)** (***p***=0.899). No significant difference was detected between **(Trunatomy**), **(Hyflex CM)** & **(2Shape)** (***p***=0.997) and (0.903). Also, No significant difference was detected between **(Hyflex CM)** & **(2Shape)** where (***p***=0.932).

TABLE (1) Mean, standard deviation (SD) values of Cutting efficiency before and after groups.

Variables	Cutting efficiency MB					
	Trunatomy		Hyflex		2Shape	
	Mean	SD	Mean	SD	Mean	SD
Pre	8.31 [b]	0.78	7.32 [b]	0.64	8.11 [b]	0.48
Post	10.58 [a]	0.88	9.45 [a]	0.75	10.99 [a]	0.86
p-value	**0.010***		**0.001***		**0.005***	

Superscripts with different small letters indicate statistically significance difference within the same column. *; significant (p≤ 0.05) ns; non-significant (p>0.05),

TABLE (2) The effect of file system on canal volume change.

Variables	Cutting efficiency	
	MB	
	Mean	SD
Trunatomy	31.02% [a]	10.79
Hyflex	31.97% [a]	6.70
2Shape	36.65% [a]	9.71
P=value	**0.899ns**	

Superscripts with different small letters statistically significance difference in the same column. ns; non-significant (p>0.05),

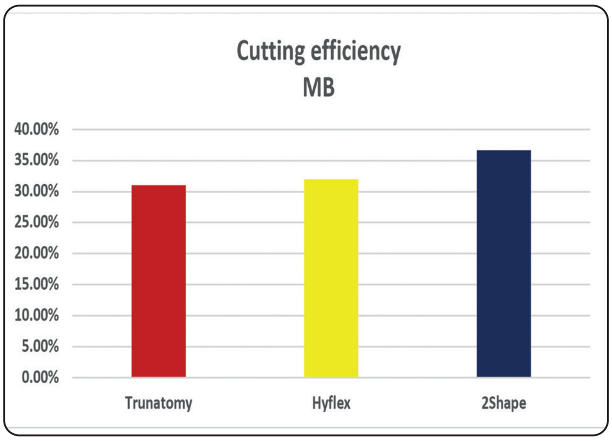

Fig. (2) Bar chart showing impact of file system on canal volume change in the MB canals.

Cleaning ability results:

Effect of mechanical preparation on cleaning ability:

Trunatomy group: The maximum mean percentage of debris was detected in (Apical) (18.09±1.81), followed by (Middle) (13.32±1.59) then (Coronal) (11.99±1.05).Significant difference was detected (Coronal), (Middle) & (Apical) (p<0.001). Significant difference was detected (Apical) and all of (Coronal) & (Middle) (p<0.001). No significant difference was detected in (Coronal) & (Middle) where (p=0.147). **Hyflex group:**The maximum mean percentage of debris was detected in (Apical) (23.80±3.27), followed by (Middle) (19.07±1.79), then (Coronal) (17.06±2.64). A significant difference was detected in (Coronal), (Middle) & (Apical) where (p<0.001). A significant difference was detected in (Coronal) and all of (Middle) & (Apical) where (p=0.023) and (p<0.001). Also, a significant difference was detected between (Middle) & (Apical) where (p=0.001). **2Shape group:** The maximum mean percentage of debris was found in (Apical)(32.75±1.44), followed by (Middle) (24.95±2.93),then (Coronal) (22.74±4.77).A significant difference was detected in (Coronal), (Middle) & (Apical) where (p<0.001). A significant difference was detected in (Apical) and all of (Coronal) & (Middle) where (p<0.001). No significant difference was detected in (Coronal) & (Middle) (p=0.363).

Effect of file system on cleaning ability:

Coronal: The maximum mean percentage of debris was found (2Shape) (22.74±4.77), then (Hyflex) (17.06±2.64), then (Trunatomy)(11.99±1.05). Significant difference was detected between (Trunatomy), (Hyflex) & (2Shape) (p<0.001). A significant difference was detected between (Trunatomy) and all of (Hyflex) & (2Shape) (p=0.004) and (p<0.001). Also, a significant difference was detected in (Hyflex) & (2Shape) where (p=0.001).

Middle: The maximum mean percentage of debris was detected in (2Shape) (24.95±2.93), followedby (Hyflex) (19.07±1.79), then (Trunatomy) (13.32±1.59). A significant difference was detected between (Trunatomy), (Hyflex) & (2Shape) (p<0.001). A significant difference was detected between (Trunatomy) and all of (Hyflex) and (2Shape) where (p<0.001). Also, A significant difference was detected between (Hyflex) & (2Shape) (p<0.001).

Apical: The maximum mean percentage of debris was detected in (2Shape) (32.75±1.44), followed by (Hyflex) (23.80±3.27), then (Trunatomy) (18.09±1.81). A significant difference was detected between (Trunatomy), (Hyflex) & (2Shape) (p<0.001). A significant difference was detected between (Trunatomy) and all of (Hyflex) & (2Shape) (p<0.001). Also, A significant difference was detected between (Hyflex) & (2Shape) (p<0.001).

TABLE (3) Mean, (SD) of Cleaning efficiency

Variables	Cleaning Ability						
	MB						
	Trunatomy		Hyflex		2Shape		p-value
	Mean	SD	Mean	SD	Mean	SD	
Coronal	11.99% ^{bC}	1.05	17.06% ^{cB}	2.64	22.74% ^{bA}	4.77	**<0.001***
Middle	13.32% ^{bC}	1.59	19.07% ^{bB}	1.79	24.95% ^{bA}	2.93	**<0.001***
Apical	18.09% ^{aC}	1.81	23.80% ^{aB}	3.27	32.75% ^{aA}	1.44	**<0.001***
p-value	**<0.001***		**<0.001***		**<0.001***		

Superscripts with different small letters indicate statistically significance difference within the same column. Superscripts with different capital letters indicate statistically significance difference within the same row.

****; significant (p≤ 0.05) ns; non-significant (p>0.05),***

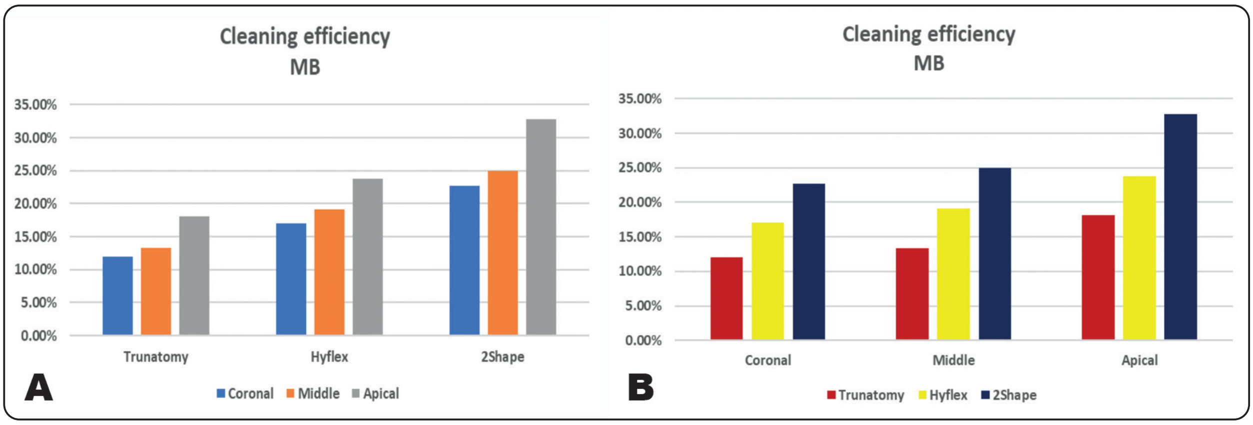

Fig (3) Bar chart representing means of Cleaning efficiency

DISCUSSION

Cutting efficiency and cleaning ability are two important features for rotary root canal instruments .Cutting efficiency is an important mechanical property which determine the cutting rate of the instrument through a given material [4, 5, 6]. Disinfection of canal is the primary goal of mechanical instrumentation to treat apical periodontitis [7, 8]. Debris was used as the criterion to assess the cleaning efficiency because dentin chips and necrotic pulp tissue might prevent effective elimination of bacteria from the canal dentin and also affect the obturation of the canal [9, 10]. The cutting efficiency and cleaning ability of an instrument are influenced by various elements, including the metallurgical qualities, surface treatment, cross-sectional shape of the shaft, sharpness of the flute, and flute design. Additional elements that can possibly have an impact include the presence of lubrication during the cutting process.[4, 5, 6].The chosen instruments in our study were selected as they have different geometrical designs and way of manufacturing [11]. TruNatomy file system was constructed using unique NiTi heat treated wire to increase its flexibility. [34]. TruNatomy files feature an off-centered parallelogram cross section. with 2 cutting edges [12, 13, 14] 2Shape is file system that is made of T_wire Heat-treated with NiTi alloy is 2Shape. This makes it more flexible and allows it to negotiate canal curvatures better. There is a triple helix in the file's asymmetrical cross section.; two 1ry cutting edge and one 2ry cutting edge aids in the optimum balance of cutting efficiency and debris elimination.[13, 11, 15]. It has only 2 contact edges during shaping same trunatomy [13].

It was proved by **Singh et al** [16] that 2Shape performed better than protaper gold in cutting efficiency and shaping ability. The Hyflex CM rotary system is a NiTi rotary instrument with form memory. It is made using a unique process that involves a complex heating and cooling treatment to manage the material's memory. [17]. This file system is made by a lower percentage of nickel weight than other files [18]. Human teeth were selected rather than other techniques such as simulated canals of plastic blocks which lacks the material qualities of human dentin, such as hardness, strength and resiliency which are important in testing both cutting efficiency and cleaning ability [19]. Proper instrumentation protocol was followed the guidelines provided by the manufacturer for all systems [20] and irrigation with NAOCL, to avoid any influences of the irrigating solution alone on the cleaning ability[9,21].Cutting efficiency was evaluated by means of measuring change of canal volume following instrumentation by the rotary files [19, 13].

Change in canal volume has been evaluated using different methods including sectioning of the specimens for measurement, CT scans and microCT and CBCT. CBCT is a practical and non-destructive way to evaluate cutting efficiency [22, 13]. For assessment of the cleaning ability .Each tooth sample was cut into 2 halves longitudinally by doing parallel longitudinal grooves using the low speed diamond disk on the outer surface of the roots without perforating the root canal. The roots split into halves with small chisel to prevent contamination of the canal [23] in order to be evaluated under stereomicroscope.Cleaning ability has been assessed by using a number of different methods including SEM and micro computed tomography[8,10]. However, the advantage of assessment using stereomicroscope compared to other techniques was its ability to provide precise overall view of the root canal rather than a selected area[9,8]. Moreover quantitative methods using digital software provided reliable non subjective results rather than traditional scoring systems as the software depends on color difference between debris and background root canal wall [8, 24].Results showed that no significant difference was detected between all tested file systems in cutting efficiency.

This can be ascribed to the fact that all systems have design features which improve cutting efficiency. Trunatomy files have off centered design which allows for more efficient cutting action, as the file engages with the dentin asymmetrically [12, 13]. 2 Shape file system has a triple helix cross section which aid in more cutting efficiency by two main cutting edges [13, 11], 2shape has 2 contact edges during shaping similarly to TruNatomy [18]. Hyflex files (20/0.04, 25/0.04) have positive rake angle [25] and a four-bladed quadrangular shape and four flutes [17] which improves cutting efficiency. Our study findings agree with **Zebouni et al** [26] where they found that there was no statistical difference found between 2shape and Hyflex CM in the cutting efficiency.Conversely, **Ewis et al** [13] found that Trunatomy had the minimal amount of dentin that removed and minimal percentage change in canal volume. They explained it by the up and down motion of TruNatomy file with slim taper which removes less dentin during canal preparation compared to the brushing motion of 2Shape and because of the smaller taper compared to Protaper Next.Regarding the cleaning ability results, significant difference was detected between the 3 files at 3 levels of canal. Where the lowest percentage of debris and highest cleaning ability was found in trunatomy group followed by Hyflex CM group then 2shape group. Similarly **Waleed and selivany** [(27)] stated that Trunatomy showed better cleaning ability than PTN, S-One Plus and WOG. The justification of result could be the distinctive design of TruNatomy files, slim NiTi design with 0.8 mm max. flute diameter. These files have off - centered parallelogram cross section and active cutting flutes. This design minimizes the risk of pathway occlusion and minimize the aggregation of dentin fragments. Similarly **Ashraf et al** [(28)] found that 2Shape produced higher amount of debris left when compared with NeoNiTi and Revo-S files.

They interpreted that this result could be due to the presence of constant cross section with three cutting blades across the file that create less room for debris to exit.**Poggio et al.** [(17)] concluded that Hyflex CM not helpful in removing debris, may because of cross section shape and flutes design . Some instruments (20/0.06, 30/0.04, 40/0.04) with A triangle cross section consisting of three blades and three flutes, others (20/0.04 and 25/0.04) with four-bladed quadrangular shape, the design of flutes may causing low capacity of removing debris & great smear layer amount making Hyflex not so helpful in showing cleanness of the root canal. Debris percentage recorded significant difference among three levels of the canal in all groups , the apical third recorded the highest debris percentage followed by middle third then the coronal third.

This could be due to the fact that the coronal portion is the widest portion of the canal which facilitate the ease of the irrigant delivery. Additionally it is difficult to evacuate debris from the apical third efficiently. Conversely, **Poggio et al.** [(17)] found statistically no significant difference in debris removal among the three portions in Hyflex CM group as it was found to be not so effective in debris removal . This could be related to the non-uniform geometry of the root canal. after using Hyflex CM in which it prevent the flushing of debris and its removal .

CONCLUSION

Within the limits of the current study: Tunatomy, Hyflex CM & 2Shape rotary files showed comparable cutting efficiencies.Trunatomy files showed better cleaning ability than the other groups. Cleaning the coronal third of the root canal was comparatively easier than cleaning the middle and apical thirds.

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