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APICALLY EXTRUDED DEBRIS ASSOCIATED WITH TRUNATOMY, 2SHAPE, GENIUS AND EDGEENDO X7 FILE SYSTEMS: AN IN VITRO STUDY

VEEN **S**GVAN **J**AMIL and **A**BDULKAREEM **R**AMADHAN **I**BRAHEEM
Dept. of Conservative Dentistry, College of Dentistry, University of Duhok, Kurdistan Region-Iraq

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ABSTRACT

Aims: The amount of apical debris extrusion after using rotary endodontic files was compared in this study.
(TruNatomy , 2Shape, Genius and EdgeEndo X7) .
Method: Forty extracted human mandibular first premolars with single canal were included. Samples were randomly divided into four groups (n = 10) according to file used for preparation of the root canal. Groups (I): the root canals were prepared using Trunatomy (II): 2Shape, (III): Genius and (IV): EdgeEndo.
The mean apically extruded debris weight in grams was estimated using the modified Myers and Montgomery experimental model. Analysis of variance (ANOVA) was used for the comparison of debris weight in the four groups. The value of significance was 0.05.
Results: Least apical debris extrusion value was produced by Genius files (0.04 ±0.01) followed by EdgeEndo (0.05±0.02) and Trunatomy (0.06±0.01), while the highest apical debris extrusion was produced by 2shape file (0.07 ±0.02). There was lower apical debris extrusion in reciprocation movement compared to continuous rotation (P=0.0001).
Conclusion: All single file systems used in this study resulted in extrusion of debris apically. Although, Genius and EdgeEndoX7 system contributed in less extrusion of debris than the other systems. Reciprocation movement extruded less debris apically compered to continues rotation.

KEYWORDS: EdgeEndoX7, Genius file, Trunatomy file, 2Shape file, apical debris extrusion, Reciprocation.

INTRODUCTION

In the root canal treatment one of the main steps is chemo mechanical preparation, which composed of mechanical preparation using instruments and irrigations. These methods could result in the extrusion of, pulpal tissue fragments, dentin chips, microorganism and its byproducts, and irrigation into the periapical area despite efforts to maintain the optimum working length (Kocak et al., 2016). Debris is currently extruded as a result of instrument systems and preparation techniques as a whole. Moreover, the amount of extruded debris could be change depends on the preparation technique and the design of the endodontic file system (Çırakoglu and Özbay,2022).

According to studies, the technique of root canal preparation, the size and type of the canal instruments, the point at which mechanical shaping will be terminated in the apical, the irrigation technique, and the total amount of solution used all have an impact on how much debris is extruded from the apical at various rates. It has also been reported that none of the existing preparation systems can form root canals without apical extrusion (Ünal and Zan, 2022). However, the new generation files produced which have different structural features, metallurgy, kinematics, and designs. They will be able to reduce complications by causing less debris extrusion if compared with conventional rotary instrument systems (Labbaf et al., 2017).

The amount of debris extruded is affected by variations in mechanical preparation techniques. When evaluating and comparing linear filing motion, less extruded debris produced by balanced force and crown-down techniques (Tanalp and Gungor, 2014). Rotary instruments frequently draw debris to their flutes, directing debris in a coronal direction out of the canal space.

Several studies compared the amount of debris extruded following canal shaping with

various file systems and techniques. Those studies found no file system capable of preparing root canals without debris extrusion (Bürklein and Schäfer, 2015). Motion and file design Kinematics have been proposed as factors influencing the amount of apical debris extrusion (Bortoluzzi et al., 2015).

Many new NiTi single file system have been introduced which are produced with advanced designs and technologies to prepare the root canal system with less adverse effects and complications The TruNatomy (TRN; Dentsply Sirona, Switzerland) were created using 0.8mm NiTi wire. After that, heat treatment is applied to file. Trunatomy files includes an orifice modifier, a glider with a centered cross-section parallelogram design, and three sizes of files for shapin, small (20/0.04 taper), prime (26/0.04 taper), and medium (36/0.03 taper) with cross-sectional design of an off-centered parallelogram (Van der Vyver, 2019). TRN files produce fine shaping and improved debridement due to the extra space created by the file's design (Dentsply Sirona, 2021).

The 2Shape (MicroMega, France) rotary endodontic file system is made up of two files: TS1 (25/.04) and TS2 (25/.06). The T-Wire technology used in file production is said to improve file resistance to cyclic fatigue. 2Shape has a latest generation of cross-section with triple helix with 2 main cutting edges for cutting efficiency and one secondary edge for improved removal of debris.

The EdgeFile X7 instruments (Edge Endo, USA) is a single-file system which is manufactured from "Heat Treated FireWire™ NiTi" alloy, which consists of a treatment and cryogenic application combination that improved file flexibility and resistance while decreasing the shape memory effect of NiTi instruments The triangular cross-sections of EdgeFile X7 have a constant 0.04 taper and a variable helical angle (Gambrini et al., 2019).

The Genius (GF; Ultraden, USA) is single file system. It is manufactured from heat-treated NiTi alloy and works on both rotation and reciprocation motions. The manufacturer suggests the usage of 0.25 mm apical diameter file with the reciprocal motion and other files (at the point of D0 with the diameter of 0.30, 0.35, 0.40 and 0.50 mm) with rotation motion. The Genius file performs the reciprocal motion in clockwise and counterclockwise directions, and the reciprocation angle (90° in clockwise and 30° in counterclockwise directions) (Gündoğar and Sezgin, 2018).

METHODS

Forty single-root extracted human permanent mandibular first premolars with straight root canals (< 10°curvature), mature apices and without noticeable root defects or abnormal morphology were included in this study which was assess with the buccal and proximal radiographs. Teeth with internal or external resorption, cracks, root canal calcification or obstruction, root caries, , pulp stones, or previous endodontic treatment were excluded in this study. The teeth were stored in 0.1% thymol crystals solutions until used. For standardization, the crowns of teeth were removed with a cutting disk at the cementum-enamel junction, leaving a root of approximately 15mm in length. Before inserting the file into the canal, 1 ml of sodium hypochlorite was used to irrigate it. The patency of the root canal was determined by inserting a hand K-file #10 into the apical foramen and then 1 ml of sodium hypochlorite. The teeth were then numbered and classified into four groups randomly (n =10).

Apical debris weight measurements

The selected container for collecting debris was glass vial, the cover of the glass vial was removed and the initial weight was determined with electronic microbalance. Each vial was given three consecutive weightings, with the arithmetic mean used to calculate the weight of each empty glass vial. The rubber cover of glass vial was holed by a surgical blade and the selected root was forced in the hole to make the root suspended in the vial. An acrylic collar made of orthodontic cold cure acrylic was made around the tooth to ensure a stable position of the root during instrumentation and to prevent any leakage of the irrigant from outside to inside the collecting vial. To balance the pressure of air inside and outside the glass vial, a 27 G needle was inserted into the rubber cover as shown in (Figure.1). The experimental model used in this study to evaluate debris extrusion is similar to that described by Myers and Montgomery in 1991.

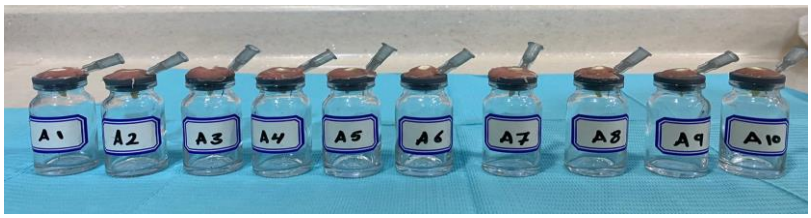

Fig.(1):- Glass vial with rubber cover used in the study with the needle inside the cover.

The specimens were randomly assigned to four groups according to the rotary file system used (n = 10) as follows:

Group 1: Trunatomy files(26/0.4) were used in full rotation direction, the rotational speed was 500 rpm and the torque limit value was 1.5 Ncm.

Group 2: 2Shape files (25/0.4) were used in full rotation direction and the rotational speed was 300 rpm and the torque limit value was 2.5 Ncm.

Group 3: Genius files (25/0.4) were used in reciprocation direction were operated at 300 rpm/3 Ncm.

Group 4: Genius files (25/0.4) were used in reciprocation direction were driven with a speed of 350 rpm and torque of 0.5 Ncm. The speed and torque of each file system was determined according to the manufacture's instructions. All canals were instrumented with VDW Silver endodontic motor.

Before starting the instrumentation glide path determination was ensured by using hand K-file #15 in gentle in-and-out motion then 1ml of sodium hypo chloride irrigation was used. Then k-file size #20 was inserted into the canal in gentle in-and-out motion then 1ml of sodium hypo chloride irrigation. The instrumentation with rotary NiTi files was done with crown down technique, in-and-out pecking motion (Roghanizad *et al.*, 2017) . Firstly the coronal third of the canal was instrumented then followed by 2 ml of sodium hypo chloride irrigation . Also the middle third of the canal was instrumented then 2ml of sodium hypochlorite was used. Finally, the file was inserted up to full working length to instrument the apical third of the canal then using of 2ml of sodium hypochlorite. Following the complete instrumentation the canal was irrigated with 2ml of sodium hypochlorite. The total amount of irrigation was standardized for all groups 12 mL 2.5% sodium hypochlorite (Al omari et al., 2021).

Individual instruments were discarded after use in each root canal in all groups, and irrigation was performed using disposable syringes with 30-gauge needles after each pecking motion during instrumentation. The teeth were removed from the glass vial and the apices of their roots were washed with 1 ml of distilled water to collect the debris that had adhered to their outer side. The glass vials were kept inside an incubator, all glass vials were incubated at 37°C for 15 days to allow the evaporation of the remaining irrigant from the glass vials (Gummadi et al., 2019). Following the incubation period, each glass vial containing debris was weighed. For each vial, three consecutive weights were obtained, and the mean value was calculated. By subtracting the weight of the empty vial from the weight of the vial containing debris, the dry weight of extruded debris was calculated.

RESULT

Table (1) Fig (2). show that the least apical debris extrusion value was produced by Genius endodontic files (0.04 ±0.01) followed by EdgeEndo X7 (0.05±0.02) and Trunatomy (0.06±0.01), while the highest apical debris extrusion value was produced by 2shape (0.07 ±0.02). The ANOVA test was used to compare the mean value of the groups., a statistically significant different was found between the study groups (P=0.0007).

Table (1): -The descriptive statistics for the mean values & the standard deviations of the apical debris extrusion among the experimental groups in mg.

Experimental groups	Statistics				p-value
	Number	Mean	Std Dev	95% CI	
Trunatomy	10	0.06	0.01	0.05 to 0.06	**0.0007**
2Shape	10	0.07	0.02	0.05 to 0.08	
Genius	10	0.04	0.01	0.03 to 0.05	
EdgeEndo X7	10	0.05	0.02	0.04 to 0.06	
ANOVA one-way was performed for statistical analyses.					

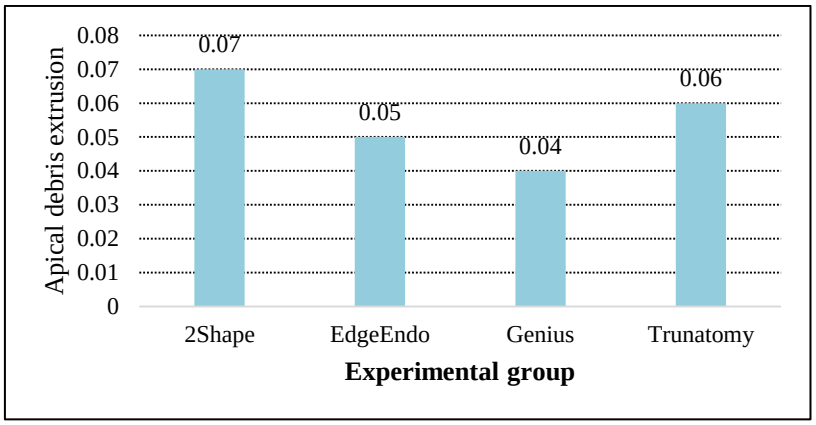

Fig.(2):- Apical debris extrusion among the experimental groups.

Table (2) shows that apical debris extrusion was significantly lower in Genius group in comparison to 2Shape and Trunatomy (p=0.0005 and p=0.0458) respectively. EdgeEndo X7 files showed statistically less debris extrusion in comparison to 2Shape (p=0.0219). Although there was no statistically any significant differences between EdgeEndo and Genius and between Trunatomy and 2Shape files.

Table(2) : -Comparisons of apical debris extrusion between study groups

Experimental groups		Statistics		p-Value
		Mean ± SD	Mean ± SD	
Trunatomy	2Shape	0.06 (0.01)	0.06 (0.02)	0.4189
Trunatomy	Genius	0.06 (0.01)	0.04 (0.01)	0.0458
Trunatomy	EdgeEndo X7	0.06 (0.01)	0.05 (0.02)	0.5006
2Shape	Genius	0.06 (0.02)	0.04 (0.01)	0.0005
2Shape	EdgeEndo X7	0.06 (0.02)	0.05 (0.02)	0.0219
Genius	EdgeEndo X7	0.04 (0.01)	0.05 (0.02)	0.5325

Tukey test was performed for post-hoc analyses.

Regarding the effect of rotational movements on apical debris extrusion, there was significantly lower apical debris extrusion in reciprocation movement groups compared to continuous rotation movement groups (P=0.0001). this indicted that the reciprocation movement extruded less debris apically compered to continues rotation groups. Table 3 and Fig. (3).

Tabl.e(3): -Comparisons of apical debris extrusion between reciprocation and full rotation groups

Experimental groups	Mean	Std Dev	p-value
Full rotation	0.06	0.01	0.0001
Reciprocation	0.04	0.01	

An independent t-test was performed for statistical analyses.

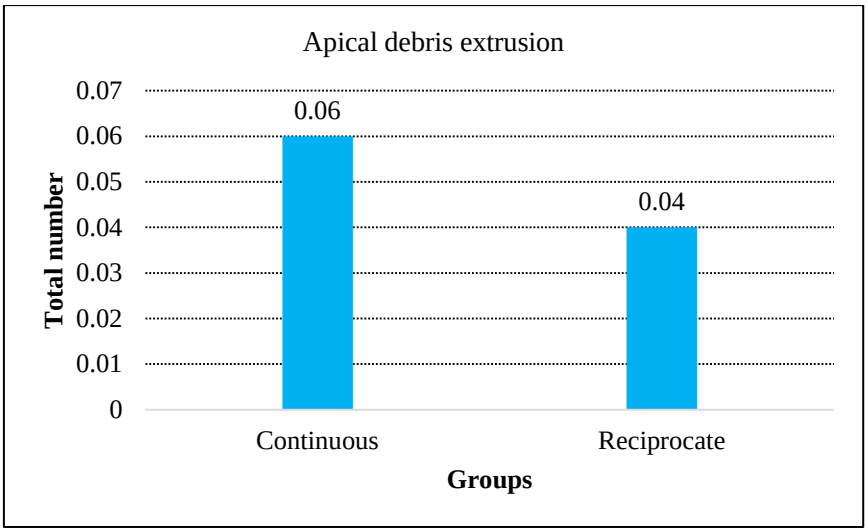

Fig.(3):- Comparison of apical debris extrusion between reciprocation and full rotation groups

DISCUSSION

Endodontic treatment success is dependent on accurate diagnosis, effective root canal dissolution, disinfection, and a tight apical and coronal occlusion data filling. Many parameters, however, influence the amount of debris extruded including preparation methods, kinematics and the design, size, and number of files used in each system (Predin et al., 2021). However, in terms of periapical response initiation, the bacterial content and antigenic features of extruded debris may be more important than the total amount of material extruded (Tanalp and Güngör, 2014). Some clinical complications, such as pain, inflammation, and slow periapical healing, are associated with apically extruded debris due to inflammatory reactions triggered by forcing contaminated and non-contaminated dentin and pulp tissue into periapical areas through or after root canal therapy (Çırakoglu and Özbay, 2021). As a result, to reduce postoperative complications, it may be necessary to avoid debris extrusion.

Rotary single file systems are widely used for their applicability in modern endodontics. The benefits of these rotary single file systems involve cross-contamination prevention, reduced working time because only one file is required to prepare all canals, and improved shaping procedure safety (Zinge and Patil ,2017).

The Trunatomy, 2shape, genius and edgefile X7 systems were chosen for this study because of their improved characteristics and performance as a result of the proprietary thermomechanical treatment they received. (De-Deus et al., 2017; Alcalde et al., 2018). These are single-file systems. Previous research has suggested that increasing the number of files used could introduce a new factor that contributes to the increased level of extruded debris (Silva et al., 2014).

To collect apically extruded debris, the widely used Myers and Montgomery, 1991 study design was used. This study design has several advantages, including practicality, simplicity, reproducibility, and the ability to compare different systems and methodologies. This study used NaOCl irrigation, which is one of the best and most widely used antibacterial irrigation solutions during root canal treatment; However, distilled water rather than NaOCl has typically been utilized in several debris extrusion tests. (Gunes et al., 2018; Elashiry et al.,2020; Djuric et al., 2021and Mustafa et al., 2021). The main reason for this choice is that NaOCl is not a sterile solution and contains sodium hydroxide ingredients (Ozlek et al., 2020). Distilled water, on the other hand, has significant disadvantages, including a lack of tissue-solving capacity, which is a necessary component of the irrigation solution for a successful root canal procedure. Additionally, because there is no tissue disintegrating action, there will be less detritus than under clinical conditions. (Parirokh et al., 2012). For these reasons, the crystallization of NaOCl was neglected in this study, and 2.5% NaOCl was used to simulate in vivo conditions.

Table (3.1) and figure (3.1) showed that a statistically significant differences between all groups regarding apical debris extrusion. This could be attributed to different files designs, mettalorgies and surface treatment. The least

apical debris extrusion value was produced by Genius endodontic files, followed EdgeFile X7, Trunatomy and 2Shape files respectively, the highest debris extrusion found in 2Shape group.

Genius files performed better than all other files ,this could be due to the design of the Genius file which has a S-shaped cross-section design with double right positive cutting angle, enhanced flutes, and a safe, non-cutting tip and, according to the manufacturer, the progressive pitch of the file during instrumentation prevents the "screw-in" effect (Drukteinis et al., 2018 ; Ultradent 2017)

In addition, the genius file move in reciprocating movement, which prepared the prepare the root canal with 90º of cutting action (CW) and 30º of release (CCW). The instrumentation finishes with a 360º rotation, removing the debris from the canal. Also, Genius files are made of heat-treated NiTi alloy and perform with both reciprocation and rotation motions. But in this study the motion of the file has been fixed to Reciprocating motion. These findings are agree with the findings of

There was no significant difference between Genius and EdgeFile X7 in apical debris extrusion, This could also be due to the EdgeFile X7's design, which demonstrated high flexibility due to the small parabolic cross-section, surface electropolishing, and thermal treatment (Khalil et al., 2018). The thermal treatment increases the file's flexibility, allowing it to keep the canal curvature and cause less canal transportation. Maintaining canal curvature has been shown to result in fewer iatrogenic defects and thus a lower potential for debris creation and extrusion. EdgeEndo X7 also has a variable helical angle. Files with constant helical angle allow to accumulate debris, whereas varying the helical angle enhances efficient debris removal (Wahed, 2021).

The results of this study are in agreement with Sowjanya et al., 2022, who found that EdgeFile X7 extruded significantly lesser amount of debris than EdgeFile X1 reciprocating and HEDM rotary file systems. But disagreed with Wahed A,2021, who found the amount of debris extruded after the use of three endodontic NiTi engine driven systems; Protaper Next, Hyflex CM and EdgeFile X7 rotary files. And found that no significant difference was detected in the amounts of debris extrusion among the experimental groups.

Trunatomy files had the highest value of debris extrusion in the rotation group, which could be attributed to the design features and geometry of Trunatomy files. Trunatomy files' reduced taper aids in the preservation of pericervical dentin. File geometry also includes variable taper, an off-center design, and a square cross-section. Heat treatment increases the elasticity and flexibility of Trunatomy files due to metallurgical phase changes from austenite to martensite (Uslu et al., 2020). Because of its regressive tapers and slim design, the Trunatomy file has been reported to improve performance with increased adaptation to the true nature of the tooth anatomy, preserving structural dentin and tooth integrity (Riyahi et al., 2020).

These results are in agreement with the study done by Al omari et al., 2021 who compared the amount of debris extrusion between Trunatomy, RACE EVO and VDW Rotate and found out that the trunatomy file extruded more debris apically compared to the other system used. Also a study done by Roshdy and Hassan, 2022 who evaluated apically extruded debris using TRUShape, TruNatomy, and WaveOne Gold. And found that Trunatomy files produced more apical debris extrusion when compared with other files.

While the results are disagreed with the study by Çırakoglu and Özbay, 2021 who found out that the Trunatomy system produced significantly less debris.

The highest amount of the apical debris extrusion was produced by 2shape files, and this could be attributed to the file design with a asymmetrical cross-section having a triple helix with two main cutting edges for improved cutting efficiency and one secondary cutting edge. This asymmetrical cross-section, therefore, provides a nonuniform and reduced contact between the instrument and the canal wall.

These results are in agreement with the study by Saricam and Kayaoglu, 2022 who evaluated the quantity of the apical debris extrusion between 2Shape, OneShape and One Curve found that the 2shape file extruded more debris than compared with other files. While disagreed with a study done by Ghoneim and Shaheen, 2018 who evaluated the extrusion of debris between 2Shape and ProTaper Universal (PTU) and found that the 2Shape system extruded less debris than the PTU rotary file system.

The current study found that all of the single file systems investigated caused apical debris extrusion, however to varying degrees as showed in table (3.1).

Regarding the effect of type of rotation (Continuous rotation vs. reciprocation) on the apical debris extrusion there was significantly lower apical debris extrusion in reciprocation movement groups compared to continuous rotation movement groups, this indicted that the reciprocation movement extruded less debris apically compered to continues rotation groups. Reciprocation is a type of balance force technique that allows for better controlling debris extrusion toward apical area. These findings have previously been evaluated, as the less extrusion of debris of reciprocating movements has been attributed to the balanced force and pressure-free methods (Ustun et al., 2015; De-deus et al., 2015). Predin Djuric et al., 2021 compared the amount of apical debris that a single-file system used for reciprocating and continuous rotation produced found that the lowest mean values were recorded by reciprocation groups. These findings agree with finding of Le et al., 2015 have shown that reciprocating systems resulted in less debris extrusion (Lu et al., 2015) Also in a study by Haridas et al. 2016 who found that reciprocating motion carry less debris apically compared to continuous rotation.

Beside that, da Silva et al., 2021 When rotary and reciprocating instruments were compared, the amount of apical debris extrusion was comparable, with no significant differences ($p > 0.05$). The controversial results of these studies regarding the debris extrusion of reciprocating and continuous rotation rotary instruments could be because of the variability of research materials and methodologies used (Mustafa et al., 2021). Regarding the instrument kinematics, it was discovered that reciprocation motion was connected to an increase in debris extrusion (Kaşıkçı et al., 2017). High-quality evidence based on the limited number of laboratory studies of four instrumentation systems evaluated, suggests that single-file instrumentation systems with reciprocating mode of rotation generate more apically extruded debris during root canal preparation as compared with single-file instrumentation systems with full rotational type of motion.

Besides taking the precautions mentioned above to standardize groups and mimic clinical conditions, research encountered some limitations. Lack of periapical backpressure and periodontal tissues were the main difficulties with the experimental design. Normally, periapical tissues form a natural barrier that helps to limit apical extrusion. However, under laboratory conditions, there is no way to avoid this. Floral foam can be used to simulate clinical conditions (Altundasar et al., 2011). The disadvantages include absorbing debris and irrigation solutions (Pasqualini et al., 2012).

CONSLUSION

Under the current study's experimental conditions, it can be concluded that all single file system(Genius, EdgeEndo X7, Trunatomy and 2Shape) used in this study extruded debris apically to different extend. Genius and EdgeEndo X7 files extrude less debris apically compared to the Trunatomy and 2Shape files. Reciprocation movement extrude less apical debris extrusion compared to continuous rotation movement.

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