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EVALUATION OF APICAL DEBRIS EXTRUSION OF TWO FULL-ROTATING INSTRUMENTS, HYFLEX EDM AND RACE EVO, VERSUS TWO RECIPROCATING INSTRUMENTS, RECIPROC BLUE AND R-MOTION: AN IN-VITRO STUDY.

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EVALUATION OF APICAL DEBRIS EXTRUSION OF TWO FULL-ROTATING INSTRUMENTS, HYFLEX EDM AND RACE EVO, VERSUS TWO RECIPROCATING INSTRUMENTS, RECIPROC BLUE AND R-MOTION: AN IN-VITRO STUDY.

Abstract

Complete cleaning and shaping of the root canal space is a mandatory stage for the success of root canal treatment. Extrusion of different materials apically during this step such as dentine debris, pulp tissue remnants, necrotic fragments, microorganisms and irrigants may occur. These extruded materials lead to periapical irritation, pain and/or swelling. To evaluate the apical debris extrusion of Race EVO and Hyflex EDM which are full-rotating instruments, versus R-motion and Reciproc Blue as reciprocating instruments. Forty extracted human mandibular premolar teeth were selected with single canals not affected by fluorosis, resorption, or fracture. Teeth were then randomly divided into four groups (n=10) according to the instrumentation files: R-motion (FKG), Reciproc blue (VDW), Race EVO (FKG) and Hyflex EDM (Colten). Extruded debris were collected and weighed using an analytical balance. All data collected from the study were statistically analyzed using the statistical package for social science (SPSS). The mean of apical debris using Race EVO and Hyflex EDM were higher than those produced with R-motion and Reciproc blue. A significant difference was observed between the four experimental groups. Race EVO and Hyflex EDM showed comparable results. No significant difference was observed for R-motion with the other experimental groups. Reciproc Blue generated significant less apical debris than Hyflex EDM and Race EVO. Reciprocating files seem to produce less apical debris extrusion than full rotation files. Reciproc Blue generated significant less apical debris than Hyflex EDM and Race EVO. R-motion showed less debris apical debris extrusion, however without significant difference. Further studies are required to find the best technique and instrument that result in minimal apical debris extrusion, thus reducing the possibility of periapical tissue irritation.

Keywords

Root canal treatment, Apical debris extrusion, Files motion, full-rotating files, reciprocating files.

1. INTRODUCTION

A complete cleaning and shaping of the root canal space is a mandatory stage for the success of root canaltreatment (Ghivari et al, 2011). Extrusion of different materials apically during this step such as dentine debris, pulp tissue remnants, necrotic fragments, microorganisms and irrigants occurs (Nevares et al., 2015), and could lead to periapical irritation, pain and/or swelling (Sen et al, 2018).

The flare-up starts within few hours or days after the root canal procedure and its severity usuallyrequires an unscheduled emergency appointment (Uslu et al, 2018). The stimulating factor of periapical injury can be either chemical, mechanical or microbial (Uslu et al., 2018). For example,in asymptomatic chronic periapical lesions any disturbance of the balance between the aggressionand the host defense caused by the extruded material may lead to an acute inflammatory response(Uslu et al., 2018). This inflammatory response can be, in an immunological aspect, the result of an antigen/antibody complex formation in the periapical area (Ghivari et al., 2011).

Apical debris extrusion is related to many factors: Natural physical factor related to the anatomy of the teeth and the mechanical factor related the mechanical instrumentation (Dincer et al, 2017).It is also influenced by the number of files used, and the design such as the taper, the cross-section,the cutting efficiency and the type of movement of the endodontic instrument (Nevares et al., 2015), (Marchiori et al., 2021). The design of reciprocating instruments such as Reciproc blue withthe S-shaped horizontal cross-section allows debris removal in a coronal direction (Marchiori et al., 2021). Also, the use of an irrigant is an important factor; according to Myers and Montgomery,it influences debris extrusion widely. A significant extrusion occurs when an irrigant is employed(Myers et al, 1991).

The file motion is an important factor that influences debris extrusion. Some authors found that full-rotating instruments cause more apical debris extrusion than reciprocating files (Dincer et al.,2017) (Arslan et al., 2016). Others found that reciprocating instruments produce much more apical debris (S. Bürklein et al, 2014) (S.Burklein et al, 2012) (Toyoğlu & Altunbaş, 2017).

Many instruments were introduced to the market, some have been used for years already, and otherswere recently introduced and their effect on debris extrusion needs to be evaluated such as ReciprocBlue from VDW, Race EVO and R-Motion from FKG.

Reciproc (VDW, Munich, Germany), a single-file system used in reciprocation, has been recentlyupdated to Reciproc Blue (REC Blue, VDW). REC Blue presents design features like Reciproc with an S-shaped horizontal cross section and 2 cutting edges, but the metallurgy of the file has been improved with a new heat treatment to make it more flexible. This new heat treatment processgives a blue color to the file (Uslu et al., 2018).

Race EVO (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) is a recently introduced full rotating file system. The heat treatment provides a good resistance to cyclic fatigue, optimized non-intrusive cutting efficiency and low screwing effect ("RACE EVO | FKG Dentaire," brochure) (AlOmari et al, 2021).

The R-Motion (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) is a reciprocating heat-treated file system instrument. As per the manufacturer, it has many properties such as high flexibility andresistance to cyclic fatigue, time saving, and minimal invasion due to small tapers ("R-Motion | FKG Dentaire," brochure.)

Hyflex EDM (Coltene-Whaledent, Altstätten, Switzerland) is a rotary file system made through an innovative manufacturing process called Electrical Discharge Machining using a controlled memory Niti wire. They have a symmetric cross-sectional design with 3 cutting edges. Unlike otherinstruments, distorted Hyflex instruments can recuperate their original shape after a sterilization procedure (Solanki, 2019).

The aim of this study was to evaluate the apical debris extrusion of Race EVO and Hyflex EDM which are full-rotating instruments, versus R-motion and Reciproc Blue as reciprocating instruments.

2. MATERIALS AND METHOD

This study was approved by the BAU institutional review board with Number 2019H-0071-D-R-0356

2.1 Sample Selection and Preparation

Power ANOVA Test (group=4, between. Var=0.013, within var=0.017, sig. level=0.05, power=0.978) was used in this study to determine the sample size. Rounding 9.98 to 10, this means we needed a total of 10x4 = 40 subjects for a power of .978. Forty extracted human mandibular premolars with single canals not affected by fluorosis, resorption, or fracture were selected and stored in a solution of 0.1% thymol (Nevares et al., 2015).

The crowns were worn with a carborundum disk until the teeth reached a total length of 15 mm to standardize the root length in all samples (Verma et al., 2017). Endodontic access was performed, and a glide path was created using a #10 file until the tip of the file could be observed in the apical foramen, and the working length was set 1mm short of the apical foramen. (Sen et al 2018). Teeth in which the #20 file had adapted in the foramen was included, and those in which the #20 file became loose or did not reach were excluded. Procedures were executed under Dental Operating Microscope (Prima, Labomed) at a magnification of 8x.

2.2 Experimental Procedure

The experimental procedure used in this study was as follows: (Myers and Montgomery,1991)

2.2.1 Experimental apparatus preparation (Fig1)

- An Eppendorf tube (Eppendorf AG, Hamburg, Germany) was numbered for each sample, and a hole was made in its lid.
- The Eppendorf tubes were individually weighed on an analytical balance (AS 220R2 Plus Radwag Poland) with an accuracy of 0.0001 g.
- The heaviest and lightest weights were discarded, and the arithmetic mean of the remaining three weights was regarded as thestarting weight of the Eppendorf tube.
- To prevent the accidental leakage of the irrigating solution during the experiment, the apparatus was covered with a rubber sheet afterfixing the root in the tube lid with pressure using cellophane sheets. The cellophane sheets were used to keep the experimenter blind.
- A 27G needle was bent and inserted in the Eppendorf lid to equalize the internal and external pressures (Kumari et al., 2019).

Fig.1: Experimental apparatus.Figure made by the Authors

2.2.2 Root canal preparation

The teeth were randomly divided into four groups (n=10) according to the instrumentation files: R-motion(FKG), Reciproc blue (VDW), Race EVO (FKG) and Hyflex EDM (Colten). In all groups, the pulp chamber and canal were initially flooded with 2mL of 2.5% sodium hypochlorite (NaOCl) before startinginstrumentation.

The VDW endodontic motor (VDW, Munish, Germany) was used in all groups. The HyFlex EDM was used in a full-rotating picking in-and-out motion during root canal shaping. The size 25 with an 8% taperwas used at a speed of 400 rpm and a torque of 2.5 Ncm. The RECIPROC Blue was used in a reciprocating picking in-and-out motion. The R25 with a size of 25 and 8% taper was used according to the manufacturer instructions (Elashiry et al, 2020). The file was operated in the “Reciproc All” mode. The R-motion was used also in a reciprocating motion under the “Reciproc All” mode. The size 25 with a 6%taper was used with gentle 2-3 mm strokes applying very light apical pressure and allowing the file to passively reach the working length (“R-Motion | FKG Dentaire,” brochure). The Race Evo was used in afull-rotating motion at a speed 800-1000 rpm and a torque of 1.5 Ncm. The file RE3 with a size 25 and 6% taper was

used as a final apical preparation with gentle 2-3 mm strokes applying very light apical pressure and allowing the file to passively reach the working length ("RACE EVO | FKG Dentaire," brochure).

During preparation, 3 mL of 3% sodium hypochlorite was used. After instrumentation, all teeth were irrigated with 2 mL 17% EDTA for 1 min, 6 mL 3% NaOCl for 3 min (2 mL/ min), followed by 2 mLof sterile saline solution for 1 min (Pedullà et al., 2019).

2.2.3 Final weighing of the Eppendorf tubes

All tubes were incubated at 70 degrees for 5 days to evaporate the remaining irrigation solution from thetubes (Kumari et al., 2019)

After the incubation period, the final weight of the tubes was measured using the same analytical balance.

3. RESULTS

All data collected from the study were statistically analyzed using the statistical package for social science(SPSS) and summarized and represented on suitable tables.

The mean extrusion weight values measured in milligrams (mg), standard deviation (SD) for each group,median values and the range of extrusion (minimum and maximum values) of the four experimental groups are presented in Table 1.

Table 1: Mean values (mg), standard deviation (SD), median values and the range of extrusion (minimum andmaximum values) of the four experimental groups.

		R_MOTION	RACE_EVO	RECIPROC_Blue	HYFLEX_EDM
N	Valid	10	10	10	10
Mean		0.0885	0.1103	0.0657	0.1089
Median		0.0950	0.1176	0.0686	0.1108
Mode		0.0706	0.0551	0.0676	0.0850
Std. Deviation		0.0141	0.0312	0.0186	0.0179
Range		0.0385	0.1089	0.0603	0.0487
Minimum		0.0706	0.0551	0.0332	0.0850
Maximum		0.1091	0.1640	0.0935	0.1337

Due to the normality of our data, a One-way ANOVA Test was used. As shown in table 2, there issignificant difference between the means of the four experiments ($P<0.05$).

Table 2: ANOVA test used to compare the debris extrusion between the four experimental groups.

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.013	3	0.004	9.544	0.000
Within Groups	0.017	36	0.000		
Total	0.030	39			

Table 3 represents the results of Bonferroni post hoc test which shows as follows:
R-Motion did not show any statistical differences from the other experimental groups. Race Evo showed comparable results to Hyflex EDM, however, it statistically generated more apical debris extrusion when compared to Reciproc Blue with significant difference. Reciproc Blue produced less apical debris than Hyflex EDM with statistically significant difference.

Table 3: Bonferroni test used to evaluate the debris extrusion in each group

Bonferroni						
(I) Experiment		**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					LowerBound	**Upper Bound**
R_MOTION	RACE_EVO	-0.0218	0.0096	0.1752	-0.0486	0.0050
	RECIPROC_Blue	0.0228	0.0096	0.1371	-0.0040	0.0496
	HYFLEX_EDM	-0.0204	0.0096	0.2423	-0.0472	0.0064
RACE_EVO	R_MOTION	0.0218	0.0096	0.1752	-0.0050	0.0486
	RECIPROC_Blue	0.0446	0.0096	0.0003	0.0178	0.0714
	HYFLEX_EDM	0.0014	0.0096	1.0000	-0.0254	0.0282
RECIPROC_Blue	R_MOTION	-0.0228	0.0096	0.1371	-0.0496	0.0040
	RACE_EVO	-0.0446	0.0096	0.0003	-0.0714	-0.0178
	HYFLEX_EDM	-0.0432	0.0096	0.0004	-0.0700	-0.0164
HYFLEX_EDM	R_MOTION	0.0204	0.0096	0.2423	-0.0064	0.0472
	RACE_EVO	-0.0014	0.0096	1.0000	-0.0282	0.0254
	RECIPROC_Blue	0.0432	0.0096	0.0004	0.0164	0.0700

4. DISCUSSION

Mechanical, chemical and microbial injuries may occur during root canal preparation (Jose F. et al., 2002). Bacteria also may be extruded along with debris in the periapical area, the type and virulence of bacteria influence the periapical inflammation (Ghivari et al., 2011).

Apical microbial extrusion may cause systemic diseases such as endocarditis, septicemia and brain abscess, especially in compromised patients (José F. et al, 2005). Therefore, periapical extrusion of intracanal material must be limited to a minimum.

This study investigated the debris extrusion of four NiTi instruments, namely: Race EVO and Hyflex EDM, R-motion and Reciproc Blue. Reciprocating instruments seem to produce less debrisextrusion than full-rotating instruments. The means of apical debris produced with Reciproc Blueand R-Motion were respectively 0.0657 and 0.0885, lower than the means of apical debris producedwith the Hyflex EDM (0.1089) and Race Evo (0.1103). A significant difference was observed between the four experimental groups. Race EVO and Hyflex EDM showed comparable results. No significant difference was observed for R-motion with the other experimental groups. ReciprocBlue showed none significant results with R-motion but generated significant less apical debris than Hyflex EDM and Race EVO.

According to this study, all files caused a certain amount of debris extrusion like other studies thatused both continuous and reciprocating file movements (Sebastian Bürklein et al, 2012) (Borges etal., 2016).

Those results are in accordance with several studies made on apical debris extrusion except the oneperformed without the irrigant (Nevares et al., 2015). When the instrumentation was not associatedwith irrigation, no extrusion of debris was observed (Nevares et al., 2015), however, this does notsimulate the clinical situation. In this study, NaOCl was used to better simulate the clinical condition. The weight of the debris extruded using this method tended to exceed that obtained witha methodology using distilled water (S. Bürklein et al., 2014) because NaOCl crystallizes after extrusion. The volume of irrigating solution and the needle position were standardized, minimizingpossible bias.

This can be in accordance with other studies that found that the files operating in a reciprocating movement cause less debris extrusion than those operating in a full-rotating

movement (Arslan etal., 2016), (Dincer et al., 2017), (Tinoco et al, 2013), (Silva et al., 2016), despite the use of distilledwater in some studies (Dincer et al., 2017) (Silva et al., 2016) and the different foramen diameter and root length (Tinoco et al., 2013).

The results of this study may disagree with other studies that found instruments used with a reciprocating movement may cause more debris extrusion than files used with a continuous rotary movement (Sebastian Bürklein et al, 2012), (S. Bürklein et al., 2014) (Toyoğlu et al, 2017). A peristaltic pump was used for irrigation in the study of Toyoglu et al (Toyoğlu et al, 2017). Distilled water was used in the study of Burklein et al (Sebastian Bürklein et al, 2012).

Whereas, some other studies found that there is no difference in the amount of debris extrusion produced using the rotary or the reciprocating files (Koçak et al., 2013) (Kirchhoff et al 2015) (Touk et al, 2019).

Many factors also may influence debris extrusion such as the number of instruments and the kinematics (Nevares et al., 2015); the multiple-file system for example extruded less debris than single files in some studies (Nevares et al., 2015), (Sebastian Bürklein et al, 2012). While in someother studies, less debris extrusion was found with the single file system (Üstün, Çanakçi et al, 2015). However, no correlation was found between the number of instruments and the extrusion of debris in other studies (Koçak et al., 2013).

The methodology used in this study was similar to that of Myers and Montgomery in 1991 (Myerset al, 1991), (S. Bürklein et al., 2014) , (Nevares et al., 2015), (Üstün et al., 2015). The tube used to collect debris has been slightly modified from the previous study. A cellophane sheet was used to cover the tube in order to limit the operator's view during the procedures. The limitations of thisstudy might be the difficulty to ideally simulate the periapical tissue and the small sample size.

5. CONCLUSION

Within the limitation of this study, all reciprocating and full rotating instruments produced apically extruded debris. Reciprocating files seem to produce less apical debris extrusion than full rotation files. Reciproc Blue generated significant less apical debris than Hyflex EDM and Race EVO. Whereas R- motion didn't show any significant difference with the other experimental groups. Race EVO and HyflexEDM showed comparable results. File motion might be able to influence apical debris extrusion. Furtherstudies are recommended taking into consideration other factors such as the file design, metal, tip, multiple versus single file system and also weighting the extruded volume before evaporation.

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