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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF THE AMOUNT OF EXTRUDED DEBRIS AFTER CANAL PREPARATION USING NEONITI, HYFLEX EDM AND PROTAPER NEXT: AN IN-VITRO STUDY

[1]Dr. Nidhi P. Solanki, [2]*Dr. Kishan, K.V., [3]Dr. Margi Parikh and [4]Dr. Krushn Savaliya

[1]BDS, MDS, Department of Conservative Dentistry and Endodontics, K.M. Shah Dental College, Sumandeep Vidyapeeth, Piparia, Vadodara, India
[2]BDS, MDS Professor, Department of Conservative Dentistry and Endodontics, K.M. Shah Dental College, Sumandeep Vidyapeeth, Piparia, Vadodara, India
[3]BDS, (MDS)3rd year Post Graduate student, Department of Conservative Dentistry and Endodontics, K.M. Shah Dental College, SumandeepVidyapeeth, Piparia, Vadodara, India
[4]BDS, (MDS)2ndyear Post Graduate student,Department of Conservative Dentistry and Endodontics, K.M. Shah Dental College, SumandeepVidyapeeth, Piparia, Vadodara, India

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***Corresponding author:* Dr.Kishan K.V**

ABSTRACT

Aim: To compare the amount of apically extruded debris during preparation with NeoNiti (Neolix, France), Hyflex EDM (Coltene) and ProTaper Next (Dentsply Maillefer, Ballaigues Switzerland). ***Materials and Methods:*** Thirty single rooted teeth were randomly assigned to three groups. The root canals were prepared according to the manufacturer's instructions using the NeoNiti (Neolix, France), Hyflex EDM (Coltene) and ProTaper Next (Dentsply Maillefer, Ballaigues, Switzerland). After that the apically extruded debris will be collected in preweighted Eppendorf tubes during instrumentation. The net weight of the apically extruded debris will be determined by subtracting the preweights and postweights of the tubes. The data will be statistically analyzed. ***Results***: The results indicated that all instruments tested caused measurable apical extrusion of debris. There was a statistical significant difference between the amounts of debris extruded by the NeoNiti and the Protaper Next (P 0.05). However, no statistically significant difference was observed between the amounts of debris extruded by the NeoNiti and Hyflex EDM, and between the Hyflex EDM and ProTaper Next rotary. ***Conclusion:*** Within the limitations of this study, it can be concluded that all rotary instrument tested produced apical extrusion of debris. The Protaper Next rotary file system extruded a significantly lower amount of debris followed by Hyflex EDM and NeoNiti.

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INTRODUCTION

The main objective of endodontic instrumentation consist of scrupulous debridement and disinfection of the root canal system, besides creating an appropriate shape to bring about the complete 3D obturation (Logani and Shah, 2008). During the root canal preparation procedures, dentin chips, pulp tissue, micro-organisms and/or irrigants may get extruded into the periradicular tissues (Tanlap *et al.,* 2006). This is of concern as material extruded from the apical foramen is associated with flare up (Seltzer and Naidorf 1985) (Different Rotary Instrumentation Systems, 2006). Chapman *et al.* (1968) were the first to validate the expulsion of infective material from the root canal system during instrumentation. Van de Visse and Brilliant (1975) then attempted to evaluate the apical extrusion of debris in root canals with or without irrigation and it Was concluded that irrigation was a procedure that facilitated the extrusion of intracanal debris periapically and that instrumentation exclusive of irrigants resulted in no collectible debris (Tanlap *et al.,* 2006). The authors also affirmed that various factors like type of irrigation, necrotic pulps, depth of file insertion into the canal, technique of biomechanical preparation and amount of coronal and middle third flaring was correlated with the amount of debris extruded (Vyavahare *et al.,* 2016). General finding of the studies investigating the amount of apically extruded debris was that the push-pull motion type of instrumentation techniquest end to produce more apical debris than instrumentation techniques using a rotational motion. This has led to the assumption that instrument systems utilizing a rotary motion will produce lesser debris. As these instruments can differ among themselves in their design and use, differences may also exist between them with regard to apically extruded debris (Logani

and Shah, 2008). Technological advancements in rotary nickel titanium instruments have led to novel design concepts and easier and quicker techniques that conserve the original canal shape with significantly less iatrogenic error (Capar *et al.,* 2014). Recently, Neo Niti (Neolix, France) rotary instruments have been introduced. Its non-homothetic rectangular section along the blade enables a progressive flexibility to better negotiate the curves and respect the canal anatomy (Neo Niti brochure). Hyflex EDM (Coltene-Whaledent, allstetten, Switzerland) is another rotary file system recently introduced. They are 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 other instruments, distorted Hyflex instruments are able to recuperate their original shape after a sterilization procedure (Hyflex EDM Brochure). Protaper Next (Dentsply, Maillefer, Ballaigues, Switzerland) is a novel Niti file system. It has an off-centred, rectangular design, generating travelling waves of motion along the active part of the file. The superior performance of the Protaper Next system is caused by the new swaggering motion, which serves to minimize the engagement between dentine and the file, to enhance augering debris out of the canal (Ruddle *et al.,* 2013; Capar *et al.,* 2014). Each of these rotary file system is known to have its unique design features, variable taper and is based on different technology. So, the differences may also exist between them with regard to apically extruded debris. Investigations of apically extruded debris using these new Niti systems with different design features and kinematics are important for understanding how the differences affect debris extrusion. However, on screening the literature on various databases like Medline, Pubmed, EBSCO shows a very scare literature on the amount of apical debris extrusion after preparation with these new Niti rotary systems. So, the present study aims to compare the debris extrusion with NeoNiti, Hyflex EDM, and Protaper Next rotary file system.

MATERIALS AND METHODS

Thirty freshly extracted human single rooted teeth, extracted for periodontal reasons will be collected from the Department of Oral and Maxillofacial Surgery. All the teeth will be disinfected by immersing the specimens in 0.5% Chloramine T solution for one week and then cleaned using ultrasonic scaler. Then the decoronation of the tooth structure will be done and the tooth will be randomly selected based on the flip coin method and will be divided into three groups as mentioned previously. After which access cavity will be prepared and working length will be established at 10X magnification using a surgical microscope (Labomed Microscope, USA) by inserting size 15 K-file to root canal terminus and subtracting 1 mm from this measurement. The debris collection apparatus was made according to the design described by Myers and Montgomery (Logani and Shah, 2008; Vyavahare *et al.,* 2016; Capar *et al.,* 2014; Tanalp and Gungor, 2014; Surakanti *et al.,* 2014; Kocak *et al.,* 2015; Ozsu *et al.,* 2014; Burklein and Schafer, 2012; Kocak *et al.,* 201). Eppendorf tubes were taken and weighed by electronic microbalance. Each individual tooth was held in a preweighed eppendorf tube which was fixed inside a glass vial through rubber plug. It was seen that no possible contact was made between the tube and the glass vial. The tube was vented with a 25 gauge needle to equalize the pressure inside and outside. Thereafter, Biomechanical preparation using hand files up to 20 k will be done and then all the instruments were set into permanent rotation using X-SMART endomotor (Dentsply, Maillefer). For each file, the individual torque limit and rotational speed programmed in the file library of the motor were used. All the preparations were made by a single operator. The preparation sequences will be as follows:

1. **Group A:** Neo Niti file was used according to the manufacturer's instructions upto 40.04 till the working length.
2. **Group B:** Hyflex EDM instruments were used according to manufacturer's recommendations upto 40.04.
3. **Group C:** Pro Taper Next instruments were used according to the manufacturer's instructions by a gentle in-and out motion in the recommended sequence upto X4 (40.06) till the working length.

The instrumentation was done till the file rotated freely. The extruded debris and irrigant during preparation were collected in eppendrof tube. A total volume of 7 mL of distilled water was used in each root canal for irrigation. The 25 gauge irrigation needle was placed short of working length or slightly coronal to the point where resistance was encountered.

Collection and weighing of extruded debris

After canal preparation, the eppendorf tube was removed from the glass vial. Then the tooth was separated from the tube and the root apex was washed off with 1 ml of distilled water that was collected in the same tube. All the eppendorf tubes were then incubated at 70°C for 5 days to allow the evaporation of moisture before weighing the dry debris (Vyavahare *et al.,* 2016; Kocak *et al.,* 2015; Ozsu *et al.,* 2014; Burklein and Schafer, 2012). For each eppendorf tube three consecutive measurements were taken on an electronic microbalance and the mean measurement for each tube was considered to be its weight. The weight of extruded debris in each tube was calculated by subtracting pre experiment weight of the tube from the weight of tube with dried debris. The mean weight of extruded debris was calculated for each group. The data were statistically analyzedusing Statistical Package for Social Science® 18Analysis was performed using F-test at a significance level of $P < 0.05$.

RESULTS

The amount of apically extruded debris was calculated by subtracting the weight of the preweighed empty polyethylene vials from the weight of vials after instrumentation and collection of debris. The mean dry weights of extruded debris were analyzed statistically using SPSS software. The Paired sample T test and Post Hoc Tukey testwere applied to determine if significant differences existed among the groups (P 0.05). The results indicated that all instruments tested caused measurable apical extrusion of debris. A significant statistical difference was found between the amounts of debris extruded by the NeoNiti and the Protaper Next (P 0.05).On the other hand, no statistically significant difference was observed between the amounts of debris extruded by the NeoNiti and Hyflex EDM, and between the Hyflex EDM and ProTaper Next rotary files.(Table 1, 2& 3)

DISCUSSION

The main aim of the present study was to evaluate and compare the amount of apically extruded debris with NeoNiti,

Hyflex EDM and Protaper Next rotary file system. In our study, a single operator prepared all the canals to eliminate the interoperator variable. A standardized protocol given by Fairbourn et al 1987 was followed to increase the probability that the amount of apically extruded debris was a result of instrumentation and to decrease the number of variables involved (Fairbourn *et al.,* 1987). Teeth used in this study were selected to have a single canal and foramina and a closed mature apex. The teeth were decoronated, which helped to obtain a fixed and reliable reference point as well as an approximately similar working length of 14mm. Pulpal tissues were removed prior to instrumentation, making sure that the debris extruded was dentinal shaving and not pulpal remnants. The amount of irrigant used in all the three techniques was kept constant at 7 ml.

Table 1. Amount of apically extruded debris after the use of the different instruments

		Mean	N	Std. Deviation	Std. Error Mean	Mean Difference	P Value
Group = 1	Pre weight	0.7935	10	0.016	0.005	0.0024	<0.001
	Post weight	0.7959	10	0.015	0.005		
Group = 2	Pre weight	0.7968	10	0.014	0.005	0.0017	<0.001
	Post weight	0.7985	10	0.015	0.005		
Group = 3	Pre weight	0.8034	10	0.013	0.004	0.0008	0.022
	Post weight	0.8042	10	0.013	0.004		

Table 2. Inter-group comparision of the amount of extruded debris

Dependent Variable	(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	P VALUE	95% Confidence Interval	
						Lower Bound	Upper Bound
Preweight	1	2	-0.0033	0.0064	0.864	-0.0191	0.0125
	1	3	-0.0099	0.0064	0.284	-0.0257	0.0059
	2	3	-0.0066	0.0064	0.563	-0.0224	0.0092
Post weight	1	2	-0.0026	0.0064	0.914	-0.0185	0.0133
	1	3	-0.0083	0.0064	0.410	-0.0242	0.0076
	2	3	-0.0057	0.0064	0.652	-0.0216	0.0102
Difference	1	2	0.0007	0.0004	0.184	-0.0003	0.0017
	1	3	0.0016	0.0004	0.001	0.0006	0.0026
	2	3	0.0009	0.0004	0.068	-0.0001	0.0019

Considering the need for accurate measurement, pure distilled water was chosen to reduce the chance of any particulate matter affecting the results. Sodium hypochlorite has the disadvantage of crystallization in the collection tube which affects the measurement of debris collection (Logani, 2008; Vyavahare *et al.,* 2016). The protocol suggested by Myers and Montgomery is an in vitro method which does not take into account the periapical tissue resistance while preparing the canal (Myers and Montgomery, 1991).

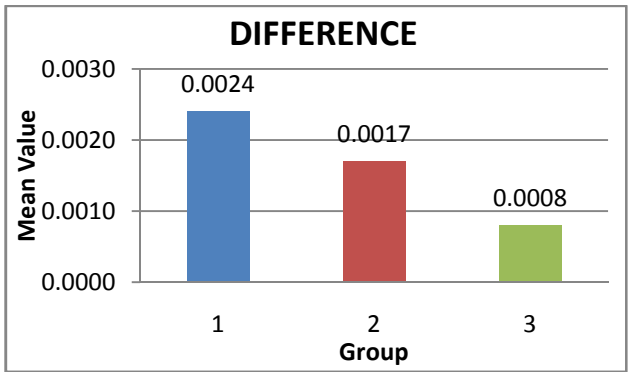

Table 3. Graph showing the intergroup comparision of the amount of extruded debris

In clinical situations, the periapical tissues act as a natural barrier to the extrusion of debris apically. The width of the apical constriction may affect the amount of apically extruded debris. Tinaz *et al.* reported that increase in the diameter of the apical preparation increases the amount of debris extrusion (Tinaz *et al.,* 2005). The size of the master apical instrument was kept constant which corresponded to the same apical diameter. The results of this study demonstrate that all instruments tested caused a measureable apical extrusion of debris. It has been shown that the instrumentation technique and the pitch design of specific instruments (Elmsallati *et al.,* 2009) influence the amount of extruded debris (Elmsallati *et al.,* 2009). The kinematics, number of files, and instrument design are also important factors in determining the shaping characteristics of rotary systems (Capar *et al.,* 2014). The maximum mean extrusion of debris was seen with the NeoNiti (Neolix, France) rotary file system followed by Hyflex EDM and Protaper Next rotary file system.

This is in agreement with a previous in vitro study which compared the quantity of debris and irrigant extruded apically using Protaper Next system to a system consisting of Hyflex and Twisted rotary file system (Capar *et al.,* 2014). It can be spectaculated that Protaper Next fifth generation rotary file system having based on M-wire technology with a characteristic off-centred, rectangular design helps to auger the debris out of the canal rather than pushing it periapically. Also, the offset design generates a traveling mechanical wave of motion along the active portion of a file. This swaggering effect serves to minimize the engagement between the file and dentin compared to the action of a fixed tapered file with a centered mass of rotation. Reduced engagement limits undesirable taper lock, the screw effect, and the torque on any given file (Ruddle *et al.,* 2001; Ruddle *et al.,* 2013). A file with an offset design affords more cross-sectional space for enhanced cutting, loading, and augering debris out of a canal compared to a file with a centered mass and axis of rotation.

Many instruments break as a result of excessive intrablade debris packed between the cutting flutes over the active portion of a file. Importantly, an offset file design decreases the probability for laterally compacting debris and blocking root canal system anatomy. The ProTaper Next files (Dentsply Tulsa Dental Specialties) operate in continuous rotary motion, and their center of mass or center of rotation is positioned off-center relative to the instrument's central axis of rotation. During rotation, the files of this design produce a mechanical wave of motion, which travels along the length of the working

part of the instrument, minimizing the contact between the file and dentin. According to the manufacturer, the offset design of this instrument also improves debris removal and flexibility in the working part of the file (Ruddle *et al.,* 2001; Ruddle *et al.,* 2013). The systems selected for assessment in this study were based on their close match in terms of tip size of the instruments used in different systems with the nature of the prepared root canals in which the final preparations of narrow and curved canals were standardized with #25 files (ProTaper Next X2 25.06) and those of large canals were standardized with #40 files (ProTaper Next X4 40.06). Hyflex EDM file systems are well known for its unwinding of spirals during root canal preparation (Burklein *et al.,* 2014). Elmsallati *et al.* (2009) compared apically extruded debris of the same instruments with short, medium and long pitch designs and showed that the short pitch design extruded less debris than the medium and long ones (Elmsallati *et al.,* 2009). The reason for the increased debris extrusion with the Hyflex system might be caused by this unwinding feature of the instruments. NeoNiti, recently introduced efficient rotary file system with a non-homothetic rectangular cross section based on EDM technology is known to be quite similar to Hyflex EDM. It is assumed to have a slightly longer pitch design than Hyflex EDM and hence more extrusion of debris apically (Shah *et al.,* 2016). Results of this study can be extrapolated to clinical conditions, but with caution because the presence of periapical and pulpal tissue may show resistance to apical extrusion of debris in clinical conditions. Furthermore, measuring the amount of extruded debris in terms of its weight is not adequate enough to make a speculation concerning a mid-treatment flare-up. There may be other factors such as extruded irrigant, intracanal medication, virulence of bacteria and the host response that can trigger such a flare-up (Tanlap *et al.,* 2006). Results of this study indicate that practitioners should be aware about the extent of debris extrusion with each specific instrument system, which can probably be made the basis for selection of a particular instrument system. Restriction of the NeoNiti and Hyflex EDM rotary file to vital and less infected teeth is one possible measure that can be taken to prevent acute Flare-ups. Similarly, the ProTaper Next file system can be used for chronic, heavily infected canals and in teeth with resorbed apices due to the lower extrusion of apical debris.

Conclusion

Within the limitations of this study, it can be concluded that all rotary instrument tested produced apical extrusion of debris. The Protaper Next rotary file system extruded a significantly lower amount of debris followed by Hyflex EDM and NeoNiti. A clinical study on the incidence of post instrumentation pain with these three contemporary Niti rotary systems would probably give a better understanding and clinical extrapolation of the results of this In-vitro study.

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