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A COMPARATIVE EVALUATION OF APICAL DEBRIS EXTRUSION BY THREE ROTARY NITI SYSTEMS- AN IN VITRO STUDY

KEY WORDS: Apical debris extrusion, NiTi rotary files, irrigation

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ABSTRACT

This study aimed to compare the amount of apically extruded debris during root canal instrumentation using three rotary file systems: ProTaper Gold, Hyflex EDM, and Flexicon X3. **Materials And Methods:** Forty-five extracted human single-rooted teeth were selected and randomly divided into three groups (n=15 per group). Standardized root canal preparations were performed using ProTaper Gold, Hyflex EDM, and Flexicon X3 rotary file systems, respectively. A No. 10 K-file was used to maintain apical patency, and instrumentation was terminated 0.5 mm short of the apical foramen. Saline was used as the irrigant throughout the procedure. Apically extruded debris was collected in pre-weighed Eppendorf tubes, dried in an incubator at 68°C for five days, and then reweighed to determine the amount of debris extruded. Data were statistically analyzed using ANOVA and Tukey's post hoc test. **Results:** All systems resulted in some degree of apical debris extrusion. The mean debris extrusion was highest in the ProTaper Gold group (0.001267 ± 0.000195 g), followed by Hyflex EDM (0.000827 ± 0.000149 g), and lowest in Flexicon X3 (0.000607 ± 0.000162 g). The differences between all three groups were statistically significant ($p < 0.05$). **Conclusion:** Although none of the rotary file systems completely prevented apical debris extrusion, Flexicon X3 was associated with the least extrusion, followed by Hyflex EDM and ProTaper Gold.

INTRODUCTION

The primary objective of root canal treatment is to reduce the number of microorganisms and the presence of pathologic debris in the root canal system. During root canal preparation, irrigants, dentin chips, pulp tissue, and microorganisms may be extruded into the periradicular tissues, which may cause postoperative pain, inflammation and failure of root canal therapy among other complications. Studies so far have proven that none of the techniques and instruments can clean and shape the root canal system without producing some apically extruded debris (AED). However, it has been proven that different instrumentation techniques have been associated with different amounts of AED(1). Hence we decided to use 3 NiTi rotary file systems to assess their AED after cleaning and shaping procedures.

ProTaper Gold (PTG, Dentsply Tulsa Dental Specialities) files have a convex triangular cross section and progressive taper. They have been developed with advanced metallurgy through heat treatment technology. They have superior flexibility and fatigue resistance properties.[(2)].

HyflexEDM nickel-titanium (NiTi) Files (Coltene-Whaledent, Allstetten, Switzerland) use Electric discharge Machining (EDM) technology. This manufacturing process gives them a unique surface and a built in shape memory, enhancing their flexibility, durability and resistance to fatigue and fracture[(3)].

FLEXICON X3 (Edgeendo, Canada) files are made of an annealed heat treatedNiTi alloy brand named Fire Wire TM. According to the manufacturer, Fire Wire Ni–Ti yields performance enhancing durability that provides incredible flexibility so that X3 files enhance and expedite the endodontic treatment[(4)]

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. The purpose of this in vitro study was to compare the apical extrusion of debris by weight in extracted single rooted teeth using above-mentionedthree rotary file systems.

Methodology

45 extracted human single rooted teeth with mature apices were selected. They were stored in 2.6% sodium hypochlorite for 2 hours to clean the periodontal tissue remnants on the root surface and were stored in 10% buffered formalin phosphate.

The teeth were divided into three groups of 15 each. Each group wasinstrumented with a different rotaryinstrumentation system. A number 10K file was carefully passed beyond the apical foramen to check andmaintain the apical patency of the root canals and working lengthdetermination was done by deducting 0.5mm from this length. All root canals were prepared till the apical diameter of 0.25mm in order to receive unbiased results.

Group 1: Protaper Gold Rotary Instrumentation:
Canals were prepared in the following files sequence: SX (coronal shaping), S1, S2, F1 and F2-at speed 300 rpm and torque 4.5 Ncm.

Group 2: Hyflex Edm Rotary Instrumentation:
Canals were prepared in the following file sequence: 25/.12 (Orifice opener), 10/.10 (Glide path file) and 25/~ (Hyflex OneFile)- at speed 500 rpm and torque 2.5 Ncm

Group 3: Flexicon X3 Rotary Instrumentation:
Canals were prepared in the following file sequence:N1(17/04), N2(17/06), N3(20/04), C1(20/06), C2(25/06) at speed 350 rpm and torque 3 Ncm.

In all the groups, canals were irrigated with total 6 ml of salineusing a 27gauge side vented needle. 5 ml ofsaline was used as an irrigant in between the files during instrumentation, with a final rinse of 1 ml after canal preparation.

Canals were prepared according to manufacturers instructions.Recapitulation and irrigation was done between each file.

A pre-weighed 10 x 75 mm Eppendorf tube was used for the study. Weight was measured using Analytical microbalance (Mettler Toledo India Pvt Ltd). The teeth were forced into a rubber stopper through the aperture which was fitted into the mouth of the Eppendorf tube such that the apical part of the root was suspended within the tube. Each tooth was thus secured for instrumentation.

The assembly was vented with a 23 gauge needle through the cap of the Eppendorf tube to equalize air pressure inside and outside the tube. The assembly was hand held vertically during instrumentation.Complete instrumentation was done by a single operator.

Immediately after canal preparation, all the test tubes with collected irrigant were stored in an incubator at 72°C for five days to evaporate the irrigant before weighing the dry debris.

Final weighing of the test tubes was then carried out on the same analytical microbalance. The difference in the weight of the tubes after and before the canal instrumentation was calculated to determine the weight of the AED.

All tubes were weighed thrice and the mean of these was calculated. The results were then tabulated and statistically analysed using ANOVA and Mann Whitney U Test.

- **Results & Statistical Analysis**

The mean debris extrusion was –
Group 1 (Protaper Gold) – 0.001267 ± 0.000195grams
Group 2 (Hyflex EDM) – 0.000827 ± 0.000149grams
Group 3 (Flexicon X3) – 0.000607 ±0.000162grams
(Table 1)

Flexicon X3 showed least apical debris extrusion, followed by Hyflex EDM, followed by Protaper Gold.

ANOVA test results indicate significance of difference between the groups($p<0.05$).(Table 2)

When comparison was done between groups, (Tukey's multiple comparison test) there was a significant statistical difference in the apical extrusion patterns of Group1 and 2, Group 1 and 3, and Group 2 and 3(Table 3)

Table 1- Descriptive Statistics

	Group 1	Group 2	Group 3
Number of cases	15	15	15
Mean	0.001267	0.000827	0.000607
SE Mean	0.00005	0.000038	0.000042
SD	0.000195	0.000149	0.000162
95 % C.I.	± 0.000195	± 0.000149	± 0.000162
Lower Limit	0.001178,	0.000738,	0.000518,
Upper Limit	0.001355	0.000915	0.000695
Minimum	0.0008	0.0006	0.0004
Maximum	0.0016	0.0011	0.001
Sum	0.019	0.0124	0.0091
Percentile			
25th	0.0011	0.0007	0.0005
50th	0.0013	0.0008	0.0006
75th	0.0014	0.0009	0.0007
Anderson Darling test			
p-value	0.38	0.458	0.074
Normality status	Yes	Yes	Yes

Table 2- Anova Test Results

	Sum of Squares	Df	Mean Square	F	p-value
Between Groups	.000003	2	.000	58.703	.000
Within Groups	.000001	42	.000		
Total	.000005	44			

p-<0.05 indicates **significance of difference.** To find exact significance we used Tukey's multiple comparison test.

Table 3- Tukey's Multiple Comparison Test

(I) VAR00001	(J) VAR00001	Mean Difference (I-J)	Std. Error	p-value	Interpretation
Group-1	Group-2	.0004400*	.0000620	.000	**Significant**
	Group-3	.0006600*	.0000620	.000	**Significant**
Group-2	Group-3	.0002200*	.0000620	.003	**Significant**

DISCUSSION

AED during cleaning and shaping procedures is responsible for postoperative inflammation and flare ups, even in teeth instrumented short of the foramen. Hence, it is important to remove the AED and its re-entry.[5]

Key factors that are responsible for AED can be categorised under: i) natural physical factors, viz. anatomy of apical constriction, root dentin hardness, quantity and momentum of irrigant flow in the root canal and the position of tooth (maxillary or mandibular)which may be affected by gravity; ii) Mechanical factors, like selection of the final apical size of instrument, instrumentation techniques, instrument design, rotation speed of the file and movements of the hand of operator during preparation.[6] As most of the natural factors are not under the control of an operator, a balancing approach towards various mechanical factors that might govern and aid in minimizing AED should be considered.

In this study, the root canals were prepared by three heat treatedNiTi rotary file systems.The NiTi alloys are usually heat treated between 450°C - 550°C, in air or inert atmosphere furnaces, to obtain superelastic or shape memory properties and to achieve the appropriate balance of mechanical properties for the application. According to a study conducted by Zinelis et al., the fatigue resistance of files was found to steadily increase from the as received state to 440°C annealing temperature and then to decrease again up to 550°C. The explanation of this behavior is associated with the thermomechanical processing and the subsequent metallurgical alterations. It can be concluded that fatigue resistance of NiTi instruments may be significantly enhanced by the appropriate heat treatment.[7] In this in vitro study, standardisation was achieved by selection of a single root, the inclusion of samples with similar canal curvature (10° to 20°), confining apical preparation to 0.25 mm with 6% taper for all samples and a common irrigation system with canal preparation done by a single operator.This leaves us with a conclusion that it is the design of the instrument and instrumentation system that is most responsible for AED in the present study.

Results of our study showed that Flexicon X3 showed least apical debris extrusion, followed by Hyflex EDM, followed by Protaper Gold, with significant difference ($p<0.05$). When comparison was done between groups, there was a significant statistical difference in the AED patterns of Group 1 and 2, Group 1 and 3, and Group 2 and 3

Hyflex EDM is a single file rotary system, whereasProtaper Gold and Flexicon X3 are multiple file rotary systems. Since debris extrusion pattern was Flexicon X3 < Hyflex EDM <Protaper Gold, we can infer that there is no co-relation between the number of files used and the corresponding apical debris extruded. Various studies have been conducted to study comparisons between single and multiple file systems. Kucukyilmaz et al. evaluated the amount of AED and irrigant using three different single and multiple nickel-titanium instrumentation systems. The single-file system tended to produce more debris and irrigant extrusion, compared with the rotary systems.[8]Saberi et al. compared the apical bacterial extrusion in canals prepared with single file versus multiple file rotary systems. Results indicated that multiple file system showed significantly less bacterial extrusion than single file system.[9]

In our study, taper of the files may have played a role in AED. The ProTaper Gold F2 instrument has a 0.08 taper, whereas the corresponding Hyflex EDM and Flexicon instruments have a 0.06 taper. The larger taper at the tip of the ProTaper Gold instrument might explain the increased amount of debris extrusion with this system.

ProTaper Gold instruments have an off-centered, rectangular design, generating traveling waves of motion along the active part of the file.

Hyflex EDM files extruded lesser than Protaper Gold due to more active cutting of dentin due to more engagement with flutes. Moreover, unwinding the spirals of Hyflex EDM occurs during the instrumentation of all specimens. This phenomenon may lead to decrease in the cutting ability and cleaning efficiency of instrument. As a result, production of dentinal chips and debris were decreased and less extrusion of debris happened in the samples.[10]

Flexicon X3 may have extruded least amount of debris apically due to the reduced taper of the files. Moreover Flexicon X3 system has no orifice opener - which conserves more dentin and causes lesser debris accumulation. The cross sectiona of this file includes radial lands, variable pitch and increasing helical angle which supports efficient removal of debris in coronal direction.[7]

However, there is not enough published literature on Flexicon files to substantiate our findings.

Gali Praveen Kumar et al. aimed to quantitatively evaluate apically extruded debris with five rotary instrumentation systems. FLEXICON file system showed lowest debris extrusion among all experimental groups.[7]

Our study did have its limitations. Studies investigating AED using extracted teeth cannot mimic in vivo conditions. It is not possible to simulate apical resistance to the debris and irrigant extrusion that is present in natural teeth due to presence of periapical tissues. Therefore, the results of this study should be carefully correlated to real clinical conditions. Further clinical studies, with a larger sample size is required to have a better understanding of this topic.

CONCLUSION

Within the parameters of this study,itcan be concluded that AED occurs in all instances of endodontic treatment, irrespective of the endodontic file systems used.

AED In Reducing Orders Were: Flexicon X3 < Hyflex EDM < Protaper Gold. When compared within groups, there was a significant difference between AED patterns seen in in all three file systems.

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