The influence of instrument application frequency on the apical extrusion of debris using rotary ProTaper, hand ProTaper and hybrid technique (An in vitro study)

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ABSTRACT

Background: Various kinds of hand-held or rotary instruments and techniques are used for mechanical preparation of the canal during root canal treatments. These instruments and techniques may push debris out of the canals which may induce inflammation within the periapical area; therefore, instrumentation technique that causes less extrusion of debris is more desirable. The aim of this study was to compare the effect of instrument application frequency on the amount of apically extruded debris.

Materials and Methods: One hundred and twenty extracted human teeth were used in this study; all teeth were shortened to a length of 15 mm. Each experimented root was mounted on a centrifuge tube that forced through a precut hole in a rubber stopper of a glass vial. The roots were divided randomly into 3 groups, each group contained 40 roots. Group R: prepared by rotary ProTaper, Group H: prepared by hand ProTaper, Group S: prepared by Hybrid technique. Each group was further subdivided in to five subgroups (A, B, C, D, and E). Debris extruded from apical foramen was collected in a centrifuge tube containing 0.5 milliliter of distilled water. Each empty centrifuge tube was weighed before preparation by 0.0001g. sensitive weighing machine. Then at the end of canal preparation, these centrifuge tubes were completely dried using an incubator at 68 C° for two days and weighed again. The difference between the weights of tubes in two stages represented the weight of debris extruded from apical foramen during instrumentation.

Results: No significant difference recorded for the mean weight of apically extruded debris regarding the instrument application frequency within the same instrumentation technique; but there was a high significant difference for the subgroups (A, B, C, and D) and a significant difference for subgroup E, regarding the effect of instrumentation techniques on amount of apical extrusion of debris among tested groups.

Conclusion: The hand ProTaper extruded smaller amounts of apical debris than the rotary ProTaper and larger amounts than Hybrid technique.

Key words: Apical extrusion, debris, ProTaper Ni-Ti files. (J Bagh Coll Dentistry 2012; 24(4):34-39).

INTRODUCTION

The most important objective of canal preparation is complete cleaning and elimination of the irritant factors for maintenance of health in periapical tissues. Dentine chips, pulp tissue fragments, necrotic tissue, microorganisms and intracanal irrigants may be extruded from the apical foramen during the canal instrumentation. This is of concern since material extruded from the apical foramen may be related to postinstrumentation pain or to a flare-up [(1)]. The interappointment flare-up is a true complication characterized by the development of pain, swelling or both, which commences within a few hours or days after root canal procedures and is of sufficient severity to require an unscheduled visit for emergency treatment [(2)].

The causative factors of inter-appointment flare-ups comprise mechanical, chemical and/or microbial injury to the pulp or periradicular tissues. Apical extrusion of the infected debris to the periradicular tissues is possibly one of the principal causes of postoperative pain [(3)].

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Various investigations have proved that in all instrumentation techniques, debris can be extruded apically and enter periapical tissues. These studies have noted that rotary systems are effective in canal preparation and they reduce the quantity of extruded debris from apical foramen [(4)]. During the last decade, root canal preparation with engine-driven nickel-titanium instruments has become popular. More recently advanced instrument designs including non-cutting tips, radial lands, different cross sections and varying tapers have been developed to improve working safety, to shorten working time and to create a greater flare within preparations[(5)]. A common finding of the studies examining the amount of apically extruded debris is that the procedures using a push-pull (filing) motion tend to produce more apical debris than instrumentation techniques that incorporate a rotational force [(6, 7, 8)]. This has led to the hypothesis that engine-driven rotary instruments will produce less debris than hand filing techniques since they have a tendency to pull the debris into the flutes of the instrument, thus leading them out of the root canal in a coronal direction. Since rotary instruments

can vary among themselves in their designs and use, differences in terms of apically extruded debris may also exist between them [9]. Studies have been performed regarding the number of instrument application frequency on the different systems such as Flex Master, Profile, and conventional hand instrumentation techniques and some recommendations have been proposed. There are many differences in various numbers of instrument applications in recutting efficiency, shaping ability, creating of smear layer, instrument fracture and forcing of debris to periapical tissues; therefore, finding the appropriate technique and application number that minimizes the extrusion of debris can help to reduce the incidence of flare-ups in endodontics[10].

The aim of this study was to evaluate and compare (using three instrumentation techniques: rotary ProTaper NiTi file, hand ProTaper NiTi file, and Hybrid technique) the effect of instrument application frequency on the amount of apically extruded debris:

a) Within the same instrumentation technique.
b) Among different instrumentation techniques.

MATERIALS AND METHODS

One hundred and twenty freshly extracted human teeth were used in this study; all teeth were shortened to a length of 15 mm by cutting the crown with a diamond disc bur. The pulpal tissue was extirpated by barbed broaches. Working length of each root canal was determined by passing a No. 15 K-file through the apical foramen. All plastic centrifuge tubes (Eppendorf tube) that were used in this study, were weighted before instrumentation, and this weight represented the initial weight (W1). Each experimented root was forced into this centrifuge tube, and then the centrifuge tube was forced through a precut hole in a rubber stopper of a glass vial. Determination of the working length was performed by insertion of file #15 to 1mm shorter than the apical foramen (Figure 1).

Figure 1: (a) Root. (b) Rubber stopper. (c) Eppendorf tube. (d) Glass vial. (e) 27 gauge needle.

Teeth were divided randomly into three groups, each group contained 40 roots as the following:-

1- Group R: Contained 40 roots that were instrumented by eight sets of rotary ProTaper Ni-Ti files.

2- Group H: 40 roots were instrumented by eight sets of hand ProTaper Ni-Ti files.

3- Group S: 40 roots were instrumented first by Gates Glidden drill then by eight sets of Stainless steel K-files instrument using Step-back technique (Hybrid technique).

Each group was subdivided into 8 subgroups; each subgroup was instrumented by one kit of instruments. Every kit of NiTi hand files was used in 5 canals so that the first number of hand file application was named "A", then the second number of hand file application was named "B", up to the fifth number which was named "E". The same thing was done for NiTi rotary files and for Stainless steel K-files.

Group R (Rotary ProTaper NiTi files):

According to manufacturer's instructions Endo-Mate (NSK. Nhkanishi Inc., Japan) were set into permanent rotation (300 revolution per minute) with a 16:1 reduction hand piece powered by a torque-limited electric motor using torque setting 2.0 Ncm. Instrumentation was completed in a crown-down manner using a gentle in-and-out motion. Instruments were withdrawn when resistance was felt and changed for the next instrument.

Group H (Hand ProTaper NiTi files):

According to the manufacturer's instructions, a crown-down technique was used, and the main principle of the crown-down technique, is cutting the canal walls by rotating the instrument clockwise with sufficient apical pressure until it engages the dentine, then rotate it counter-clockwise to disengage and remove the file from the canal.

Group S (Gates Glidden drill and Stainless Steel K-files):

The roots in this group were instrumented using the Hybrid technique. The coronal two thirds of the canals were prepared initially using Gates Glidden drill size 4, 3 and 2. Apical instrumentation commenced using Step back technique and used in reaming action (one-half turn) and withdrawn a few millimeters while lateral force was applied against canal walls (rasping motion). The same instrument was used repeatedly against all walls until it became loose at the full working length. All canals were enlarged up to size 30 K-file as a master apical file (MAF) then step-back sequence was started using reaming motion with circumferential rasping on the outward stroke [11].

Debris extruded from apical foramen, were collected in a centrifuge tube containing 0.5 milliliter of distilled water that were mounted in a glass vial. To balance the air pressure inside and outside of the tube, a 27-gauge needle was placed into the tube. For drying of distilled water inside the tubes, all the centrifuge tubes were incubated in an incubator (Memmert-Germany) for two days at 68°C [(12)].

Debris weighing

Before starting canal preparation, the weight of each empty centrifuge tube was recorded by a 0.0001 g. Sartorius weighing machine (Sartorius Analytical, Germany), this weight value represented (W1). Final weighing (W2) that represented extruded debris and centrifuge tube (Figure 2) was recorded after drying of all remaining distilled water and after root removal, the difference between the initial and the final weight was recorded as the net weight of apically extruded debris.

Figure 2: Dry debris collected in an Eppendorf tube.

RESULTS

All the three instrumentation techniques and all the application frequencies induced extrusion of debris with different values from the apical foramen.

a. The effect of instrument application frequency on apical extrusion of debris within the same group (same instrumentation technique):-

The results of ANOVA test for all groups (R, H, and S), comparing A, B, C, D, and E of the same group, recorded that there was no significant difference (P>0.05). Figure (1.3) represented the mean weight values of apically extruded debris for all groups (R, H, and S).

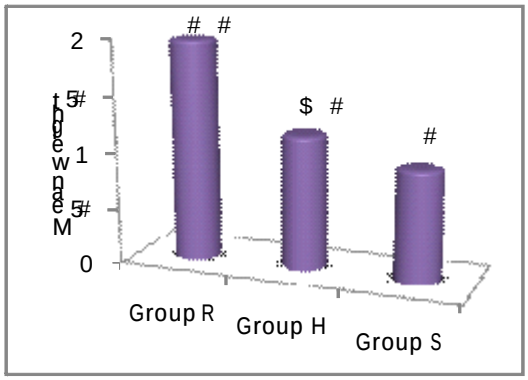

Figure 3: Bar chart of mean weight values (in mg.) for group (R, H, and S).

b. The effect of instrumentation techniques on the amount of apical extrusion of debris among groups (different instrumentation techniques):-

Another comparison of apically extruded debris weight was performed by ANOVA test among subgroups (A, B, C, D, and E) and the results indicated that there was a high significant difference (P<0.0001) for subgroup (A, B, C, and D) and a significant difference (P < 0.05) for subgroup E. Mean weight values of apically extruded debris for subgroups A, B, C, D, and E were shown in Figure 4 and Table 1.

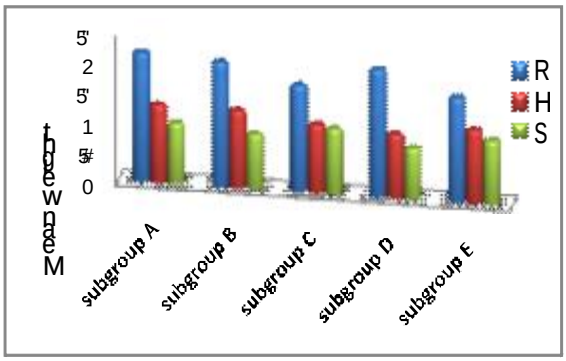

Figure 1.4: Mean weight values (in mg.) among subgroups (A, B, C, D, and E).

Table 1: Student's t-test results of debris weights for all the subgroups (A, B, C, D, and E).

	Compared Subgroups	t- value	P- value	Mean Difference	Standard Error	Sig.
A	R vs. H	4.475	.001	0.85000	.18992	S*
	R vs. S	6.194	.000	1.13750	.18365	HS**
	H vs. S	2.043	.060	0.28750	.14071	NS***
B	R vs. H	4.625	.000	0.78750	.17028	HS
	R vs. S	6.913	.000	1.16250	.16817	HS
	H vs. S	2.729	.016	0.37500	.13742	S
C	R vs. H	3.803	.002	0.63750	.16764	S
	R vs. S	4.506	.000	0.68750	.15258	HS
	H vs. S	0.341	.739	0.05000	.14684	NS
D	R vs. H	5.840	.000	1.06250	.18194	HS
	R vs. S	7.462	.000	1.27500	.17087	HS
	H vs. S	1.545	.145	0.21250	.13750	NS
E	R vs. H	2.880	.012	0.51250	.17797	S
	R vs. S	4.184	.001	0.67500	.16133	S
	H vs. S	1.196	.252	0.16250	.13587	NS

DISCUSSION

Mid treatment flare-up is a common problem that practitioners may encounter during the root canal therapy. A major reason cited for such a distressing occurrence is the extrusion of debris present within and created during the instrumentation of the root canal system into the periradicular region, resulting in a persistent periapical inflammation.

Many researchers have looked at various aspects of apically extruded debris. The results have shown that preparation up to the apex, the diameter of apical patency, the amount and type of irrigant used, formation of a dentin plug, the use of a step-back versus crown-down technique, and the use of conventional hand filing versus rotary motion (instrumentation technique), also the type of teeth used, instrument designs including noncutting tips, radial lands, different cross sections and varying tapers that have been developed to improve working efficiency and safety, all these factors may have correlations to the amount of extruded debris, in the present study, ProTaper nickel-titanium (Ni-Ti) instruments and Stainless Steel K-files were used since these instruments have become popular in dental clinics [13-16].

The type of used teeth has a very important role. In this present study freshly extracted, single human straight palatal roots, of maxillary first and second molars have been used, because using one type of teeth can increase the similarity and standardization among specimens [17]. Because of Irrigation is a necessary and important phase of cleansing the canal; and in order to obtain an accurate measurement and standardization, distilled water, that was completely pure, was used in this study to reduce the chance that particulate matter, contained in other irrigants, might possibly skew the final values. In this way, the weights of the tubes in both situations (without distilled water and after drying) were similar, and the debris extrusion effects of instrumentation technique could be investigated.

In this study, it was noted that in all specimens, the apically extruded debris was recorded but with different values, that is in agreement with many studies results [12, 16, 18, 19] who found that all the instrumentation techniques extruded debris apically.

a. The effect of instrument application frequency on the apical extrusion of debris within the same group (same instrumentation technique):-

In the present study, the results comparing the number of instrument applications in each group (Group R, H, and S) revealed no significant differences (P>0.05) among the groups; this means that debris extruded by any instrument was not affected by first, second, third, fourth or fifth application of that particular instrument, these results coincide with Zarrabi et al.[16]; who recorded no significant difference for instrument application frequency on the amount of apical extrusion of debris for conventional step back technique and Flex Master system; and disagree with him for Profile system since a significant difference was recorded.

b. The effect of instrumentation techniques on the amount of apical extrusion of debris among groups (different instrumentation techniques):-

In the present study, debris was extruded in all of the instrumentation methods. The mean amount of extrusion in group R (Rotary ProTaper NiTi file) was higher than that of the other two groups, which were group H (hand ProTaper) and group S (hybrid technique), there was a highly significant difference between the three groups for subgroups (A, B, C, and D) respectively, and a significant difference for subgroup (E); These results may be attributed to:-

1. Rotary ProTaper NiTi files is a faster and aggressive preparation system with its characteristic flute design features, which may remove a substantial amount of dentine in a shorter period of time. As well as it is unable to displace the debris coronally with the same efficiency as it cuts, and thus poses a risk of increased apical extrusion of debris [12].

2. The long pitch design of the ProTaper instruments may cause a greater amount of debris to be extruded [20].

Similar results have been also established by several studies [12,21,22]. However, Nazari & MirMotalebi [23] found that the least amount of extruded debris was associated with ProTaper system in comparison to Stainless Steel K-file and NiTi Flex Master file; this may be due to the lack of early coronal flaring, during preparation for Stainless Steel K-file group, that results in less apical extrusion of debris by reducing the amount of dentin available to be pushed apically and creating a space large enough for debris to be rinsed away in a coronal direction as it is generated, whereas in our study early coronal flaring was done by using Gates Glidden drill [6, 24, 25].

Within the ProTaper system, hand ProTaper instruments (group H) were used according to the manufacturer's instructions in a crown down technique, and scored lower mean extrusion of debris compared to the rotary ProTaper (group R); there was a highly significant difference between the hand and rotary ProTaper NiTi instruments in terms of extrusion of apical debris for subgroups (B and D); and a significant difference for subgroups (A, C and E), according to the results of Student's t-test as shown in Table (1.1). These results were in agreement with Logani & Shah [12]. On the other hand, these results disagree with Ghivari et al. [26] who found that hand ProTaper extruded debris higher than rotary ProTaper; and this may be due to the continuous rotary motion and rotational speed of rotary ProTaper NiTi files inside canal, whereas, for hand ProTaper, the rotational speed of the file is an "operator controlled variable factor" extruding less amount of debris.

In the present study and according to the results, and in comparison with other groups (rotary ProTaper and hand instruments); the lowest mean values of debris extruded apically recorded for group S (Gates Glidden drill and Stainless Steel K-file) using Hybrid technique, there was a highly significant difference in comparison to rotary ProTaper for all subgroups except for subgroup E; which showed a significant difference in term of apically extruded debris, Also there was no significant difference for all subgroups in comparison with hand ProTaper, except for subgroup B, which reveals a significant difference in term of apically extruded debris. These results were in disagreement with some studies [23, 18, 26] who found that higher amount of debris was extruded when using Stainless Steel K-file in comparison with other groups. This disagreement may be attributed to:-

1- They used a filing motion in the apical third (in and out motion), which acted as a piston that tends to push the debris through the foramen and less space is available to flush it out coronally [27].

2- They did not perform an early coronal flaring during preparation that contributed to the high reduction in the amount of apically extruded debris and creating a space enough for rinsing out the debris in the coronal direction [6, 11, 25].

3- In the present study, early coronal flaring done with Gates Glidden drill sizes 4,3 and 2 then using Step back technique in reaming action (one-half turn) and without using filing motion, then withdrawn a few millimeters while lateral force was applied against canal walls [28].

It must be emphasized that the results of this study should not be directly extrapolated to clinical situations. No attempt was made to simulate the presence of vital pulp or periapical tissues, and an in vivo model might give different results, as periapical tissues may serve as a natural barrier, inhibiting debris extrusion. Results may also differ because of positive and negative pressure at the apex [29] and with normal or pathological periapical tissues. Furthermore, this study was limited to teeth with mature root morphology. The observed results should not be generalized to teeth with immature root development and open apices.

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