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Comparison of apically extruded debris of different nickel titanium instruments

Dr. Diyar Kh. Bakr, B.D.S., M.Sc., Ph.D.*

Abstract

Background and objective: During root canal instrumentation irrigants, necrotic pulp tissue, microorganism and dentin debris may be extruded beyond the apex into the periradicular tissue. These extrusions may cause flare-up. The purpose of this study was to compare the amount of apically extruded debris with three rotary Nickel titanium instruments.

Methods: Sixty single rooted, single canalled premolars were selected. The roots were divided randomly into three groups; (n = 10) according to the type of instrumentation system used, group 1"ProTaper Next" system, group 2 "One Shape" system and group 3 "Mani Silk" system. The Debris extruded during the instrumentation was collected and dried in preweighed vials and the amount of extruded debris was assessed with an electronic balance.

Result: results showed that the Mani silk system extruded significantly less debris than the ProTaper Next and One shape systems ($P < .05$), and there is no significant difference in apically extruded debris between ProTaper Next group and One Shape group but the One Shape produced more debris than ProTaper Next.

Conclusion: the Mani silk file instrument was behaved well during instrumentation and extruded less debris than the other groups.

Key words: Apically extruded debris, ProTaper Next, One Shape, Mani Silk, Rotary file.

Introduction

Root canal treatment is considered as the most effective method of treating pulpitis and periapical periodontitis.[1] Accordingly the successful endodontic treatment based on debridement, disinfection and obturation, during cleaning and shaping dentin chips, pulp tissue fragments, necrotic tissues, microorganism and irrigant may be transported and extruded into the periradicular tissues.[2, 3,4] The extrusion of microorganism, debris and irrigant beyond the apex may disrupt the balance between microbial aggression and host defense, causing postoperative complication, called (flare up). Flare up is described as the occurrence of inflammation. Pain, swelling and delay healing of periapical tissue, the incidence of these postoperative complications is reported to range between 1-4% to 16%. The intensity of acute inflammatory response depend on the number and/or virulence of the microorganism. All instrumentation techniques cause apical extrusion of debris and bacteria

* Lecturer, College of Dentistry, Hawler Medical University

to some degree, depending on, preparation of root, design of file system, canal/apical foramen size and irrigation solution.[5, 6,7.]

Currently more than 50 instrument systems are available for cleaning and shaping, most of it involve NiTi instrument with differences in cross-section design, cutting blade design, taper, type of alloy, number of file used, flexibility and concept of use.

ProTaper Next (PTN) rotary system (Dentsply Maillefer, Ballaigues, Switzerland) is encompassed of a set of instruments that are designed with variable tapers and an off-centered rectangular cross section that manufactured with an M-wire raw material, which was shown increasing the flexibility and resistance to breakage.[8]

One Shape from (Micro- Mega, Besancon, France) is designed to completely prepare root canals with only 1 instrument. It is used in continuous rotating motion in contrast with other system single file systems that are used in vibration motion or reciprocation motion that required special automated device. It has three variable cross-section in the same file. The file comes in size 25 and 6.0% taper, must be used at speed of 350-450 rpm and 4.5N torque with pecking motion.[9]

Mani silk file from (Mani-Japan) have three file in each pack; simple pack (08/25, 06/25, 06/30) instrument and standard pack include (08/25, 06/20,06/25), while complex pack encompass (08/25, 04/20, 04/25), according to the manufacture instruction by these three packs can effectively shape any canals. The silk can be used with any torque controlled endodontic motor in continuous rotary motion. Silk has a unique tear drop cross-section which allows the debris to be directed out of the canal efficiently and keep the file centered in the canal to reduce canal transportation.[10]

The present study was designed to compare the apically extruded debris when the root canal instrumented with these three files. The null hypothesis was that these three different files that have different cross-section design would have no effect on the extrusion of debris during instrumentation.

Material and Method:

Sixty Mandibular premolars with mature apices and straight root canal were selected from a collection of teeth that has been freshly extracted from patients (aged 15–35 years) for periodontal and orthodontic reasons. Soft tissue and calculus will remove mechanically from the root surfaces with a periodontal scaler. The teeth will verify radiographically as having a single root canal without calcification.

To facilitate instrumentation and eliminate any variables in access opening, all the teeth were decoronated at cement-enamel junction area leaving 14 mm root length by using a slow speed conventional straight hand-piece with diamond disc.

Pulpal tissue was removed by using barbed broach and size #10 stainless steel K-file is move down in the canal until the file is just visible. Endodontic working length will be set by deducting 1 mm from these lengths. Moving a #15 K-file down to the working length controls the size of the apical foramen. When the K-file extruded beyond the apical foramen, the tooth was excluded from the study. The specimens were then randomly divided into 3 experimental groups (n = 20) according to the instrument system to be used: the PTN, MS, or OS. Only new instruments were used in each tooth.

In this study the experimental model described by Myers and

Montgomery in 1991 was used. In preparation for weighing, a hole was created on the rubber stopper of a vial, and a tooth was inserted until the tooth stayed 1–2 mm above the stopper. A 27-G needle was placed alongside the stopper as a drainage cannula also to balance the air pressure inside and outside the tube. Then, each vial with the tooth and the needle were covered by rubber dam to shield the operator from seeing the root apex during instrumentation.

Preweighing of the glass vial

Stoppers were separated from the glass vials. An analytical balance (Radwag, Radom, Poland) with an accuracy of 10^{-6} g was used to measure the weights of the vials. six consecutive weights were obtained for each vial, and the average was calculated.

Root Canal Instrumentation with the ProTaper Next (PTN)

The files were used in X- smart motor operated at 300 rpm and at 300 N-cm torque (X-Smart, Dentsply Tulsa Dental). The X1 file (17/.04, Dentsply Tulsa Dental) was used with a brushing motion until resistance was felt in the canal. The file was then with- drawn, cleaned, and inspected before being reused for instrumentation. The canal was rinsed with distilled water, and a #10 K-file (Dentsply Tulsa Dental) was used to confirm patency. These procedures were repeated until the X1 file reached the WL. The canal was rinsed with distilled water. The same procedures were performed with the X2 file (25/.06, Dentsply Tulsa Dental). A total amount of 4 mL distilled water was used by using a 27-G side-vented tip needle during each instrument change. To standardize the irrigation protocol, It was irrigated the canal at flow rate of 1ml/min by using a special irrigation device (VATEA), the irrigating needle during irrigation inserted into the canal within 1 mm from the working length without binding and moved in an up-and-down motion.

Root canal instrumentation with one shape (OS)

Canal instrumentation was done with One Shape file in a continuous rotary motion at speed of 400 rpm, and the torque was adjusted to 4 Ncm. Instrument was removed and cleaned regularly to remove debris and the canal irrigated with distilled water. Once the instrument had negotiated to the end of the canal and had rotated freely without engagement, it was removed. At this point, the preparation of the canal was judged to be complete. A total amount of 4 mL distilled water was used by using a 27-G side-vented tip needle during each instrument change. To standardize the irrigation protocol, It was irrigated the canal at flow rate of 1ml/min by using a special irrigation device (VATEA), the irrigating needle during irrigation inserted into the canal within 1 mm from the working length without binding and moved in an up-and-down motion.

Root canal instrumentation with Mani Silk (MS)

Ten root canals prepared using Mani Silk at 500 rpm and 3 N-cm torque controlled endodontic motor. The Silk 0.08/25 files advanced in the canal to 3 to 4 mm in a brushing motion. Then the canal irrigated with distilled water and patency of the canal confirmed. After that the middle file 0.06/20 was inserted in the canal until reached the apex for 3 seconds, followed by irrigation, then the last file 0.06/25 was advanced in the canal until reached the apex for 3 seconds. A total amount of 4 mL distilled water was used by using a 27-G side-vented tip needle during each instrument change. To standardize the irrigation protocol, It was irrigated the canal at flow rate of 1ml/min by using a special irrigation device (VATEA), the irrigating needle during irrigation inserted into the canal within 1 mm from the working length without binding and moved in an up-and-down motion.

Postweighing of the Glass Vial

When the instrumentation was complete, the stopper, the needle, and the tooth were separated from the vials, and the debris adhered to the surface of the root were collected by washing the root with 2 mL distilled water inside the vial. The vials were then stored in an incubator at 60 C for 5 days for evaporation of the distilled water before weighing the dry debris. Then A second examiner who was blinded to the group assignment performed weight calculation. The glass vials were weighed using the same analytical balance to obtain the final weight of the vials including the extruded debris. six consecutive weights were obtained for each vial. The dry weight of the extruded debris was calculated by subtracting the weight of the empty vial from that of the vial containing the debris.

Statistical Analysis

Statistical analysis was performed using SPSS version 21.0 software (SPSS Inc, Chicago, IL). Debris extrusion in the same group was analyzed using the ANOVA test. To compare the results among groups, post hoc Tukey test used. The level for accepting statistical significance was set at $P < .05$.

Results

The means and standard deviations of the 3 experimental groups were calculated and tabulated (Table 1). Inter-group comparison of mean number of apically extruded debris was done by using analysis of variance (Table 2). Post hoc pair-wise comparison was done by using the Tukey test (Table 3). The level of significance was set at .05.

From ANOVA table, there was a significant difference between three experimental groups at the 0.05 levels. Tukey HSD showed that there is no significant difference in apically extruded debris between ProTaper Next group and One Shape group but the One Shape produced more debris than ProTaper Next. On the other hand the Mani Silk group significantly produced less debris than other groups.

Discussion

In this study, a standardized tooth model was used to increase the probability that the amount of apically extruded debris was a result of instrumentation and reduce the amount of variables. The teeth used were carefully selected according to tooth type, age of patient, canal size, number of canals, and canal curvature to ensured that the apical extrusion of debris was due to the instrumentation technique and not due to canal configuration and tooth morphology.

Root canal curvature and presence of more than one root canal are factors that may affect the final amount of apical extrusion of debris.[11] Therefore, in this study, only single- rooted teeth with straight canals were used to eliminate variables that might interfere with final results.

The working length was kept 1 mm short of the apical foramen and working length measurements were confirmed with radiograph. This was confirmed with the studies by Myers and Montgomery[12], and Martin and Cunningham[13,] who have demonstrated greater apical debris extrusion when canals were instrumented to the apical foramen or at a length where the file was observed to just protrude through the apical foramen versus 1 mm short of the apical foramen.

A single operator prepared all the canals to overcome variations. The side-vented needles used in all the groups for irrigation to avoid irrigation extrusion.[14] Moreover, for standardization of the irrigation protocol, the irrigation was passively provided with a device at constant flow rate.

Distilled water was used as an irrigation solution instead of sodium hypochlorite to avoid any possible crystallization of sodium hypochlorite that could change the weight of dentin debris and compromise the reliability of the results.[15]

In the present study three newly developed file (PTN, OS and MS) were used. These systems were chosen because each one of have different instrumentation systems, unique instrument design, manufacturing methods in a peculiar type of root canal anatomy, to our knowledge, no studies have assessed apical debris extrusion with MS compared to OS and PTN).

All engine-driven systems used in this study work in continuous rotation, and a file with continuous rotation is considered to act like a screw conveyor improving transportation of dentin chips and debris coronally. [16] Hence, the differences found between the 3 experimental groups may be attributed to variation in file design.

Results obtained from the present in vitro study showed that all three systems used extruded debris apically and no method could completely prevent debris extrusion Therefore, the techniques and systems that minimize the amount of apically extruded debris should be sought.[15, 17-19] Over the years, apical extrusion of intracanal debris and materials have been investigated in many studies because of its clinical relevance.[14, 20-26]

According to the results obtained from the current study, the obtained differences between the instruments might have been caused by the instrumentation technique, the different taperness of instruments and the cross-sectional design of the instruments. PTN is characterized by rectangular cross-sectional design, OS is characterized by Variable cross-section, and MS is characterized by tear shape cross-section.

It was clear that instrumentation with MS system resulted in the least extrusion while more debris extruded was resulted with PTN and OS systems, and the difference was statistically significant ($P < 0.05$), a tendency toward less debris extrusion was observed in the MS system could be attributed to unique characteristic, a Teardrop"-shaped cross section, this design channels debris out of the canal efficiently and centers the file (maintaining the canal path) which increases the available volume for upward debris elimination which may contribute to the production of less debris extrusion apically. In addition, the teardrop cross-section decreases the "screwing in" effect and simultaneously improves tactile sensation.

There are many previous studies that evaluated the apically extruded debris with PTN system.[24-29] The PTN have a unique design which is an offset center of mass and rotation. This design provides better cross-sectional space for enhanced cutting, loading and successfully allowing the dentin debris to transport out of a canal (coronally), compared to a file with a centered mass and axis of rotation. The new swaggering motion, which serves to minimize the engagement between dentin and the file and enhances auguring debris out of the canal. It may also decrease the chances for the file packing the debris laterally, aiding in reducing the chances of blockage of the root canal system.[8] This might be explaining the result of this study that the PTN produced less debris extrusion than OS with no significant difference statistically.

In this study the greater amount of debris extrusion shown with OS system than PTN and MS systems. One Shape is a single-file system with variable cross section, with apical 2 mm presenting with 3 cutting edges, followed by a transition zone in next 7.5 mm and 2 cutting edges most coronally along the blades. The 3 cutting edges guide the file down the canal, whereas the 2-cutting-edge zone in the coronal portion offers optimal cutting. It has positive rake angle, variable, progressive pitch, and constant taper of 6%, preparing the canal in shorter period of time. All these features in the file systems may contribute to production of increased debris.

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Table (1): The descriptive statistics for the mean values & the standard deviations of apically extruded debris for the three experimental groups

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
PTN	20	.56218	.099271	.022198	.51572	.60864	.441	.781
OS	20	.61645	.109365	.024455	.56527	.66763	.439	.791
MS	20	.47580	.096072	.021482	.43084	.52076	.334	.643
Total	60	.55148	.115796	.014949	.52156	.58139	.334	.791

Table (2): One Way ANOVA for the difference of apically extruded debris between groups.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.201	2	.101	9.724	.000
Within Groups	.590	57	.010		
Total	.791	59			

Table (3): Tukey HSD test for the difference of apically extruded debris between each pair of the three groups.

(I) factor		(J) factor		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
dimension2	PTN	dimension3	OS	-.054270	.032169	.219	-.13168	.02314
			MS	.086380*	.032169	.025	.00897	.16379
	OS	dimension3	PTN	.054270	.032169	.219	-.02314	.13168
			MS	.140650*	.032169	.000	.06324	.21806
	MS	dimension3	PTN	-.086380*	.032169	.025	-.16379	-.00897
			OS	-.140650*	.032169	.000	-.21806	-.06324
*. The mean difference is significant at the 0.05 level.								