MDJ

Evaluation of apically extruded debris by using hand and rotary Nickel-Titanium instruments

Dr. Jamal A. Mehdi, B.D.S., M.Sc (Prof.)
Dr. Iman M. Al-Zaka, B.D.S., M.Sc (Assistant Prof.)
Dr.Amer Al-Obiedy, B.D.S., M.Sc (Assistant Lecturer.)

Abstract

This study evaluated the amount of apical debris, using hand, rotary ProTaper instruments, and rotary ProFile instruments. Forty five of mandibular premolars with single root were randomly divided into three groups. The teeth in all groups were instrumented until reaching the working length, with ProFile, rotary ProTaper and hand PrpTaper instruments. Debris extruded from the apical foramen was collected into preweighed polyethylene vials and the extruded irrigant was evaporated. The weight of the dry extruded debris was established by comparing the pre-and post instrumentation weight of polyethylene vials for each group. All instruments tested produce a measurable amount of debris, a statistically significant difference was observed between ProTaper instruments and ProFile group in term of debris extrusion ($P < 0.001$). Although ProTaper rotary extruded a relatively higher amount of debris, no statistically significance difference was observed between this type and the ProTaper hand instruments ($P > 0.05$).

Key words: apical extrusion, ProTaper system, NiTi instruments.

Introduction

The goals of endodontic instrumentation include thorough debridement and disinfection of the root canal system, in addition to creating a suitable shape to achieve a complete 3D obturation[1]. In an effort to obtain these goals, debris such as dentinal shavings, necrotic pulp tissue, bacteria and their byproducts or irrigant may be extruded into the periradicular tissue. The extruded material has been referred to as a 'worm' of necrotic debris and has been cited as a major cause of mid-treatment flare-ups[1,2].

The causative factors of inter-appointment flare-ups comprise mechanical, chemical and/or microbial injury to the pulp or periradicular tissues[3,4]. Apical extrusion of infected debris to the periradicular tissues is possibly one of the principal causes of postoperative pain [5].

Studies have shown that almost all instrumentation techniques produce apical debris to some extent[6,7], Vande Visse and Brilliant[8] first quantified the amount of debris apically extruded during instrumentation. They found that instrumentation with irrigant produced extrusion, whereas instrumentation without irrigant produced no collectible debris. A common finding of the studies examining the amount of apically extruded debris was that the instrumentation techniques using a push-pull motion tend to produce more apical debris than instrumentation techniques using a rotational motion [9,10].

Martin and Cunningham[10] reported that less debris was extruded when the intracanal preparation was accomplished with an ultrasonic instrument. Reddy and Hicks[11] compared apical debris extrusion between hand and engine-driven Ni-Ti instruments, comparing the mean weights of apically extruded debris, showed that step-back instrumentation produced significantly more debris than the two engine-driven Ni-Ti techniques.

During the last decade root canal preparation with engine-driven Ni-Ti instruments has become popular. More recently advanced instrument designs including non-cutting tips, radial lands, different cross sections and varying tapers have been to improve working safety, to shorten time, and to create a greater flare of preparations[12]. In the progressive ProTaper system (Dentsply Maillefer, Ballaigues, Switzerland), the shaping files (S) have an increasing taper from tip to coronal, whereas the finishing files (F) have a decreasing taper. Bergmans et al.[12] found that the increasing taper instruments have enhanced flexibility in the middle region and at the tip, and that the decreasing taper instruments provide a larger taper in the important apical region but make them stiff. Also ProTaper rotary instruments have a convex triangular cross-sectional design, a non-cutting safety tip and a flute design that combines multiple tapers within the shaft [13].

The ProFile rotary instrument (Dentsply Maillefer, Ballaigues, Switzerland) reported to have a U-shape cross section with radial lands and parallel central core. The tip size of these instruments are similar to those of ISO normed instruments with even greater tapers and 19mm lengths[12]. Bidar et al.[14] compared between step-back technique and ProFile 0.04 taper rotary system at different speeds, in debris extrusion, they found that rotary technique could reduce the amount of debris extrusion.

As these instruments can vary among themselves in their design and use, differences may also exist between them with regard to apically extruded debris. The ProTaper hand, ProTaper rotary and ProFile are three contemporary instrumentation systems preferred for their shaping and time-saving ability. The purpose of this study was to evaluate and compare the amount of apically extruded debris using these three systems.

Materials and method

In this study, forty five freshly extracted mandibular premolar teeth were used. All teeth were analyzed with digital radiographs (EvaCo. USA) in buccal and proximal directions to check for a single canal. Teeth with calcification and open apices were excluded and one apical foramen and mature apices were selected. Teeth were immersed in 2.5% sodium hypochlorite for two hours, the soft tissue remnants on the external root surface were removed with a periodontal curette and then stored in 10% formalin solution. Teeth were decoronated from the cemento-enamel junction, and the pulp tissue removed with barbed tissues. A size 15 file was extended just beyond the apical foramen to ensure that the root canals were patent before instrumentation. The working length was established by subtracting 1mm from this length. No other files were passed out the apical foramen again. All teeth were coded and then randomly assigned to 3 groups of 15 specimens each.

Instrumentation and debris collection:

Debris collection was performed in keeping with technique described by Myers& Montogomery[9]. The teeth were forced through a hole in the rubber stopper. Before canal instrumentation, a glass shell vial preweighed with Analytic Balance was placed into the plastic bottle. During the measurement of empty vials in the Analytic Balance, three consecutive readings were taken and the average value was recorded. The rubber stopper with the tooth was then fitted into the mouth of a plastic bottle. The apical part of the root was suspended within the vial, which acted as a collecting container for apical debris and irrigant extruded through the foramen of the root. The plastic bottle was vented with a 25-gauge needle along side the rubber stopper during instrumentation to equalize the air pressure inside and outside the apparatus. Instrumentation was performed by a single operator. The operator was shielded from seeing the root apex during the instrumentation procedure by a rubber dam that obscured the plastic bottle. The series used for each instrumentation technique was as follows:

Group 1 (ProFile group):

Each canal was prepared mechanically to the working length with rotary endodontic instruments Profile taper .04, taper .06 (Dentsply, Maillefer, Switzerland) using a slow speed handpiece (300 rpm) with crown-down technique in the following manner:

A profile #25 taper .06 is used to about 1/2 of the canal followed by #25 taper .04 to about 2/3 of the canal in crown down manner, this is to prepare the coronal portion of the canal, for the apical portion, profile #15 taper .04 used to the working length followed by profile #20 taper .04, #25 taper .04, #25 taper .06, #30 taper.04, #30 taper .06 sequentially used to the working length.

Group II (ProTaper rotary group):

All canals were prepared mechanically with the ProTaper system (Maillefer, Ballaigues, Switzerland) a system made up of six instruments. According to the manufacturer's recommendations, using a low speed hand piece (300rpm) with crown- down technique, For coronal portion of the canal start with shaping file S1 to achieve straight line access with brushing movement once resistance felt remove the file and force against the canal walls on its removal, this action performed just to remove any cervical interference. After that shaping file SX is used with the same manner. When the canal is patent and working length is confirmed with #15, shaping file S1 is reused to the working length with brushing motion, followed by shaping file S2 used with the same manner till it reached the working length. The apical portion is prepared with finishing files, first start with F1 file to working length followed by F2 file to the working length. Finally use F3 file is used to working length its tip size equal to #30 file, with that instrument the preparation of the apical portion is completed.

Group III (ProTaper hand group):

Thirty canals were prepared manually with the ProTaper hand files (Maillefer, Ballaigues, Switzerland) a system made up of six hand instruments. According to the manufacturer's recommendations, the canals were prepared with crown down technique, For coronal portion of the canal start with shaping file S1 to achieve straight line access with gently rotating the handle clockwise until the file is just snug, then the file is disengage by rotating the hand counter clockwise 45-90 degrees. The dentine cut by rotating the handle clockwise while simultaneously the file is withdrawing, repeat handle motions until desired length is achieved. After that the shaping file SX is used with the same manner. When the canal is patent and working length is confirmed with #15, shaping file S1 is reused to the working length with the same motion, followed by shaping file S2 used with the same manner till it reached the working length. The apical portion is prepared with finishing files, first start with F1 file to working length followed by F2 file to the working length. Finally use F3 file is used to working length its tip size equal to #30 file, with that instrument the preparation of the apical portion is completed.

Irrigation was conducted in a similar manner, in all three groups. Sterile water after each instrument was used; 0.5ml of sterile water was delivered over a 15-second time period using 27 gauge needle on insulin syringe (1ml). The needle tip inserted passively and never allowed to bind as the irrigant was being deposited into the canal. Same irrigation procedure applied to all teeth. Debris adhering to the outer surface of the root apex was collected by washing of the apex with an additional milliliter of sterile water into the vial. The vials were stored in an incubator at 68°C for two days to evaporate the irrigant before weighing the dry debris(15). Weighing was carried out on an Analytic Balance. Three consecutive readings were noted for each sample and the average value was recorded. The amount of apically extruded debris was calculated by subtracting the weight of the preweighed empty vials from the weight of vials after instrumentation and collection of debris.

Statistical analysis:

Data were analyzed statistically using one-way analysis of variance (ANOVA), and least significant test (LSD). The level of statistical significance was set at $P=0.05$.

Results

The mean extrusion values (g), standard deviation (SD), are presented in table (1). The results indicated that all instruments tested caused a measurable apical extrusion of debris. A high statistical significant difference was observed between the amounts of debris extruded by the ProTaper rotary and the ProFile, and between the ProTaper hand and ProFile ($P < 0.001$) table(2&3). On the other hand, no significance difference was found between the ProTaper rotary and the ProTaper hand ($P > 0.05$). The highest mean of apically extruded debris was shown in ProTaper rotary group Fig.(1).

Discussion

Root canal instrumentation requires technical knowledge to be applied to the biological area, so as to obtain a well instrumented and disinfected canal without damage to its biological structure. Since the root canal includes the space that contains the pulpal organ, one of its ends is in the pulp chamber and the other(s) corresponds to the apical foramina. Thus, instrumentation of root canals can cause extrusion of material through the foramen by virtue of the anatomy of the canal itself [16].

The main objective of the present study was to evaluate and compare the amount of apically extruded debris with the ProTaper hand, ProTaper rotary and ProFile systems. In this study, a single operator prepared all the canals to eliminate the interoperator variable. A standardized protocol 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. Teeth used for this study were carefully selected to have a single canal and foramina and a closed mature apex. The teeth were decoronated at the CEJs, which helped to obtain a fixed and reliable reference point as well as an approximately similar working length of 20mm. Pulpal tissue was removed prior to instrumentation, making sure that the debris extruded was dentinal shaving and not pulpal remnants. The size of the master apical instrument was kept constant, the ProTaper hand and rotary F3, and the ProFile 0.06/30 which corresponded to the same apical diameter of size 30[12].

The ProTaper systems (hand and rotary) have characteristic features which include a progressive taper and a modified guiding tip. They demonstrate a new, convex, triangular cross-section design, which results in a reduced contact area between the dentin and the cutting blade of the instrument, allowing it to achieve a greater cutting efficiency[17]. They also have active cutting blades with a positive rake angle. Their design features include a variable helical angle and balanced pitches, which allow for debris removal and prevent the instrument from screwing into the dentinal walls of the canal[17]. A significant advantage of the ProTaper system is a reduction in the number of instruments which saves time and operator fatigue[13]. The results of this study demonstrate that all instruments tested caused a measurable apical extrusion of debris, the highest mean of apically extruded debris showed in ProTaper rotary group. This is in agreement with other in vitro studies[18,19].

Azar & Ebrahimi[18]compared the quantity of debris and irrigant extruded apically using the ProTaper system to a system consisting of the ProFile and K-flex file. The maximum mean extrusion of debris was seen with the ProTaper rotary.

Tanalp et al.[20] quantitatively evaluated the amount of apically extruded debris when the ProTaper, ProFile and HERO Shaper systems were used for the instrumentation of the root canals. They concluded that the ProTaper rotary caused a significantly higher amount of debris extrusion compared to the ProFile system[20]. Logani&Shah[15]noted that preparation with ProTaper rotary instruments extruded more debris. It can be speculated that a faster, aggressive system with its characteristic design features, which removes a substantial amount of dentin in a shorter period of time is unable to coronally displace the debris with the same efficiency as it cuts and hence, poses the risk of increased apical extrusion of debris. Even though ProFile has more number of instruments to complete the shaping, it probably provides a slower and gradual approach to the apex. Furthermore, the final file of the ProTaper system F3 has an apical taper of 0.09, which is larger than ProFile that has a 0.06 taper. The larger taper of F3 instrument increases the stiffness of the tip and the use of larger and greater taper apical file perform more aggressive cutting and this could be another cause of the more apically extruded debris by ProTaper hand and rotary.

Zarrabi et al[21] reported that ProFile system extruded less debris than other rotary instrument It has also been suggested that the unique 'U' file design of this system encourages coronal rather than apical displacement of debris. The 'U'-shaped grooves provide the space to accommodate dentinal shavings while planing the canal walls. The 20° helical angle is designed to remove the debris coronally while the instrument rotates clockwise. The slight negative rake angle and radial lands make the file cut less aggressively than those having an active cutting blade.

Although there is no significant difference between ProTaper hand and rotary, the ProTaper hand had lower mean extrusion compared to the ProTaper rotary, probably explaining its use in the modified balanced force technique. The balanced force permits a controlled pressure of the instrument inside the root canal, allowing better removal of debris adhering to the files [22].

It must be emphasized that the result of this study should not be directly extrapolated to the clinical situation. No attempt has been made to simulate the presence of vital pulp or periapical tissues, an in vivo model may give different result, as the periapical tissues may serve as a natural barrier, inhibiting debris extrusion. Results may also differ because of positive and negative pressure at the apex and with normal or pathological periapical tissues.

Conclusion

Based on the results, it can be concluded that all hand and rotary instruments tested produce apical extrusion of debris. The ProTaper rotary extruded a significantly higher amount of debris than the ProFile.

References

1- Stewart GG. The importance of chemomechanical preparation of the root canal. *Oral Surg Oral Med Oral Pathol.* 1955;8:993–997.

2- Seltzer S, Naidorf IJ. Flare-ups in endodontics: I. Etiological factors. *J Endod.* 1985;11:472–478.

3- Torabinejad M, Kettering JD, McGraw JC, Cummings RR, Dwyer TG, Tobias TS. Factors associated with endodontic interappointment emergencies of teeth with necrotic pulps. *J Endod.* 1988;14:261–266

4- Siqueira JF., Jr Microbial causes of endodontic flare-ups. *Int Endod J.* 2003;36:453–63.

5- Wittgow WC, Jr, Sabiston CB., Jr Microorganisms from pulpal chambers of intact teeth with necrotic pulps. *J Endod.* 1975;1:168–171

6- Mckendry DJ. Comparison of balanced force, endosonics and step back filing instrumentation techniques: Quantification of extruded apical debris. J Endod 1990;16:24-7.

7- Al-Omari MA, Dummer PM. Canal blockage and debris extrusion with eight preparation techniques. J Endod 1995;21:154-8.

8- Vande Visse IE, Brillant JD. Effect of irrigation on the production of extruded material at the root apex during instrumentation. *J Endod.* 1975;1:243–246.

9- Myers GL, Montogomery S. A comparison of weights of debris extruded apically by conventional filings and canal master techniques. J Endod 1991;17:275-9.

10- Martin H, Cunningham WT. The efect of endosonic and hand manuplation on the amount of root canal material extruded. *Oral Surg Oral Med Oral Pathol.* 1982;53:611–613.

11- Reddy SA, Hicks ML. Apical extrusion of debris using two hand and two rotary instrumentation techniques. *J Endod.* 1998;24:180–183

12- Bergmans L, Van Cleynenbreugel J, Beullens M, Wevers M, Van Meerbeek B, Lambrechts P. Progressive versus constant tapered shaft design using Ni-Ti rotary instruments. *Int Endod J.* 2003;36:288–295

13- Bergmans L, Van Cleynenbreugel J, Wevers M, Lambrechts P. Mechanical root canal preparation with NiTi rotary instruments: Rationale, performance and

safety. Status report for the American Journal of Dentistry. *Am J Dent.* 2001;14:324–333.
14-Bidar M, Rastegar FA, Chaziani P. Evaluation of apically extruded debris in conventional and rotary instrumentation techniques.CDA.2004;32:665-671.
15-Logani A, Shah N. Apically extruded debris with three Ni-Ti instrumentation systems: An ex vivo comparative study. Indian J Dent Res.2008;19:182-185.
16-Vansan LP, Pecora JD, Silva RG, Savioli RN. Comparative in vitro study of apically extruded material after four different root canal instrumentation techniques. Braz Dent J.1997;2:79-83.
17-Cohen S, Burns RC, eds. Pathway of the pulp.9th ed. St. Louis: CV Mosby, 2006.
18-Azar NG, Ebrahimi G. Apically extruded debris using the ProTaper system. Aust Endod J 2005;31:21-23.
19-Kustarci A, Akdemir N, Siso HS.Apical extrusion of intracanal debris using two engine driven and step-back instrumentation techniques: An in-vitro study. Eur J Dent.2008;2:233-239.
20-Tanalp J, Kaptan F, Sert S, Kayahan B, Bayirl G. Quantitative evaluation of the amount of apically extruded debris using three different rotary instrumentation systems. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:252-9.
21-Zarrabi MH, Bidar M, Jafarzadeh H. An in vitro comparative study of apically extruded debris resulting from conventional and three rotary (Profile, Race, FlexMaster) instrumentation techniques.J Oral Sci.2006;48:85-88.
22-Al-Omari K, DummerP. Canal blockage and debris extrusion with eight preparation technique. J Endod. 1995;21:154-162.

Table(1): Descriptive statistics showing the mean and stander deviation for each group

Instrument type group	Total(n)	Mean extrusion(mg)	Std.deviation
ProFile system	15	0.555	0.21
PrpTaper rotary	15	1.0247	0.4177
Protaper hand	15	0.846	0.16809

Table (2): ANOVA test

	DF	SS	MS	F	P
Between groups	2	1.6834	0.8417	10.22	0.000
Within groups	42	3.4575	0.0823		
total	44	5.1409			

Table(3): Multiple comparison test(LSD)

Groups	Mean difference	P	sig
I&II	-0.469	0.001	***
1&III	-0.290	0.001	***
II&III	0.178	0.119	NS

***: Highly significant , NS: Non significant

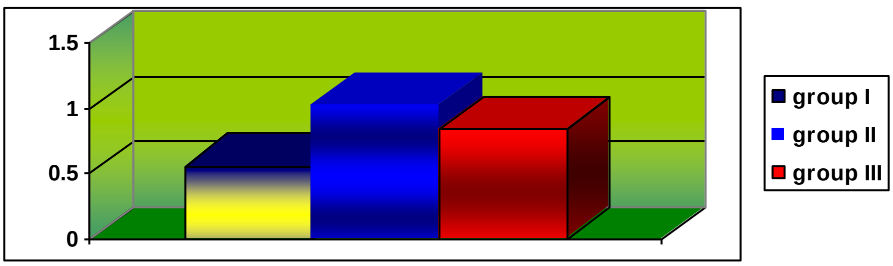

Fig.(1): Bar chart showing the means of extruded debris for each group.