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International Journal of Current Research
Vol. 10, Issue, 03, pp.67457-67464, March, 2018

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

COMPARATIVE EVALUATION OF DEBRIS EXTRUDED APICALLY DURING ENDODONTIC RETREATMENT USING HEDSTROM FILES AND TWO ROTARY NICKEL TITANIUM (NITI) INSTRUMENTS, K3 AND PROTAPER UNIVERSAL RETREATMENT FILES

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ARTICLE INFO

Article History:
Received 21st December, 2017
Received in revised form
17th January, 2018
Accepted 19th February, 2018
Published online 30th March, 2018

Key words:
Endodontic retreatment,
Hedstrom files,
Pro Taper Universal Retreatment instrument,
Modified step-back flare technique,
Eppendorf tube.

ABSTRACT

Aim: To evaluate and compare the amount of debris extruded apically during Endodontic retreatment using manual Hedstrom and rotary k3, ProTaper Universal Retreament instruments.

Materials and method: 45 Extracted human single straight rooted mandibular first premolar teeth were used in this study. After the conventional access cavity preparation and working length determination, cleaning and shaping was done with a modified step back flare technique using Gates Glidden drills and K-files to a master apical file size of #30 and stepped back in 1-mm increments with four subsequent instrument sizes #35, #40, #45, #50 K-file. Obturation was done with 0.02 taper Gutta percha points and AH PLUS root canal sealer in a cold lateral condensation technique. Plastic Eppendorf tube of capacity 2ml was used as the collecting container for any debris or irrigant extruded apically from the tooth during retreatment. Grouping was done as follows Group I- Control group – No gutta-percha removal, Group II-Gutta-percha removal with Hedstrom files, Group III-Gutta-percha removal with K3 files, Group IV-Gutta-percha removal with Protaper Universal Retreatment files. The Eppendorf tubes were stored in an Incubator at 37 ºC for 21 days to evaporate the irrigant before weighing the dry debris. The tubes with the dried debris were weighed using the Analytical balance. Weight of extruded debris= Weight of Eppendorf tube with dried debris MINUS Pre-weighted weight of empty Eppendorf tube.

Results: Observations were then statistically analyzed using Analysis of variance (One way ANOVA) and the difference among four groups were evaluated by students 't' test for pair wise comparision. There was a statistical significant difference among all the groups in the amount of debris extruded except group III and IV.

Conclusion: All retreatment techniques resulted in debris extrusion during Endodontic retreatment. Retreatment with manual Hedstrom files resulted in significantly greater extrusion of debris when compared to rotary K3 and ProTaper Universal Retreatment instruments.

Citation: Dr. Priyanka, Y., Dr. Murali Krishnam Raju, S., Dr. Shreyas Gujjar and Dr. Sita Rama Kumar. Manthena, 2018. "Comparative evaluation of debris extruded apically during endodontic retreatment using hedstrom files and two rotary nickel titanium (niti) instruments, K3 and protaper universal retreatment files", *International Journal of Current Research*, 10, (03), 67457-67464.

INTRODUCTION

When endodontic retreatment is performed, irritants in the form of filling materials, necrotic pulp tissues, bacteria, or irrigants may be undesirably introduced into the periapical tissues.

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The apically extruded materials are held clinically responsible for postoperative inflammation and flare-ups, even in teeth instrumented short of the apical foramen (Seltzer *et al.,* 1985; Siqueira *et al.,* 2003; Huang *et al.,* 2007). All the instrumentation techniques promote apical extrusion of debris to some degree (Mary Kinue Nakamune *et al.,* 2010; Vitoriano *et al.,* 2013; McKendry *et al.,* 1990; Reddy *et al.,* 1998; Ferraz *et al.,* 2001). However, the amount of debris extruded apically might vary according to the technique used. Therefore,

appropriate retreatment technique should be selected to remove the preexisting filling material as completely as possible while minimizing the amount of apical extrusion. Rotary systems have been proposed as an alternative to hand instrumentation for removing guttapercha. Recently, two new designs of Nickel Titanium rotary instruments, k3 (SybronEndo, West Collins, USA) and Protaper universal retreatment files (Dentsply Tulsa, Tulsa, Ok) have shown good ability for removal of root canal filling. The purpose of the present study is to compare the amount of debris apically extruded during endodontic retreatment using two rotary Nickel Titanium (NiTi) instruments (K3 and Protaper universal retreatment files) and manual Hedstrom files.

MATERIALS AND METHOD

Teeth Selection: Forty five freshly extracted human single straight rooted Mandibular first premolar teeth, recently extracted for Orthodontic reasons from patients aged between 20 - 25 years were used in this study. Selection of teeth was based on their relative dimensions and similarity in morphology. The Inclusion criteria was teeth with a single root, single straight canal, verified radiographically in buccal (Fig.1) and proximal directions (Fig. 2), one apical foramen, mature apex with #15K file fitting snugly at the working length. The Exclusion criteria was teeth with caries, cracks, fractures or craze lines, calcifications, resorptions and open apices. The teeth were washed under running tap water to remove blood clots and were cleaned of debris and soft-tissue remnants with the help of a sharp sickle scaler. Later the teeth were kept in normal saline solution in a humidor at room temperature until being used.

Endodontic treatment

Access cavity preparation: The Buccal cusp edge of each tooth was flattened with a tapered fissure bur to serve as a reference point. Access cavities were prepared with Endo Access bur in a high speed hand piece with water coolant. Pulp tissue remnants were removed using fine barbed broach taking care not to engage the canal walls. Working length determination: Apical patencies were determined with a size-10 K-file. The working length was established 1.5 mm shorter than the length at which a size-10 K-file was visualized at the apical foramen. 0.5mm was calculated as safety factor. Cleaning and shaping- Root canal preparation was performed with a modified step-back flare technique. The coronal portion was initially flared with sizes 1- 3 Gates Glidden drills in a sweeping upward motion. Canals were then prepared in a sequential order starting with #15 K-file at the working length to a master apical file size of #30 and stepped back in 1-mm increments with four subsequent instrument sizes #35, #40, #45, #50 K-file. Irrigation with 2 mL of 3% Sodium Hypochlorite (NaOCl) and recapitulation was done after every instrument. Each instrument was used for the preparation of only three teeth. When instrumentation of the root canal was complete, 17% EDTA solution was applied for 1 minute to remove the smear layer, and the canal was flushed again with 3% NaOCl and saline solution to remove remnants of EDTA.

Obturation: The root canals were dried with sterile paper points. Obturation was done with 0.02 taper ISO size 30 master gutta-percha point which fit snugly at the working length and the remaining space was filled with accessory gutta percha points and AH PLUS root canal sealer using finger spreaders in a cold lateral condensation technique. With the help of a calibrated heated hand plugger the gutta percha was seared off to a point at which the remaining length of root canal filling was 16 mm from the apex to the coronal aspect. The depth of plugger insertion for searing off the gutta percha was calculated by subtracting 16mm from the working length for each sample. This assured the standardization of the filling material. The obturated samples were radiographed in the buccal (Fig. 3) and proximal directions (Fig. 4) to confirm the adequacy of root canal filling. The access cavities were sealed with cotton pellet and Cavit W. All the teeth were then stored in humidor at 37^{o}C and 100% humidity for 2 weeks to allow complete setting of the sealer.

Experimental Design: An Eppendorf tube is a laboratory centrifuge tube. Microcentrifuge tubes are typically of capacities ranging from 250 µl to 2.0 ml. Plastic Eppendorf tube of capacity 2ml was used as the collecting container for any debris or irrigant extruded apically from the tooth during retreatment. The group numbers were carved on the Eppendorf tubes. The excess particles as a result of carving were completely removed with alcohol soaked cotton pellet before weighing. These Eppendorf tubes were weighed with an Analytical balance of 10^{-4} precision (Balança analítica Marte – SHIMADZU AY220, Santa Rita do Sapucaí, MG, Brazil). Three consecutive measurements were taken for each tube, and the mean value was recorded. Holes were made in the custom made acrylic stoppers of Eppendorf tubes. Teeth were inserted through the holes and were fixed at the Cement Enamel Junction with self-cure acrylic resin in order to create a hermetic seal (Fig. 6,7,8). A bent 27-gauge needle was placed through the stopper to balance the atmospheric pressure with that of the Eppendorf tube. The Eppendorf tubes were then fitted into the glass vials. All vials were covered with aluminum foil to prevent the operator from viewing debris extrusion during the retreatment phase. The entire apparatus was handled only by the outer vial.

Retreatment technique: The teeth were randomly divided for retreatment into three groups of 15 teeth each. Group I-Control group – No gutta-percha removal, Group II-Gutta-percha removal with Hedstrom files, Group III-Gutta-percha removal with K3 files, Group IV-Gutta-percha removal with Protaper Universal Retreatment files. Cavit W was removed with a round bur. 0.1 mL of xylene was first placed into the access cavity to soften the root filling material. Two or three additional drops of solvent were applied as required to reach the working length.

Irrigation Regimen: During retreatment, a total volume of 12 ml distilled water was used to irrigate the root canal of each tooth. The irrigant was delivered with a disposable plastic syringe with an attached 27-gauge stainless steel needle. 2ml Irrigant was delivered periodically during gutta percha removal.

Group I- Control group- No gutta percha removal

15 Eppendorf tubes containing 0.2 ml distilled water were used as control which were dried and measured (Fig. 5).

Group II- Gutta-percha removal with Hedstrom files

The canals were retreated with Hedstrom files in sizes 20, 25 and 30 using a circumferential quarter-turn push-pull filing

Figure 1. Bucco-Lingual radiographs of specimens

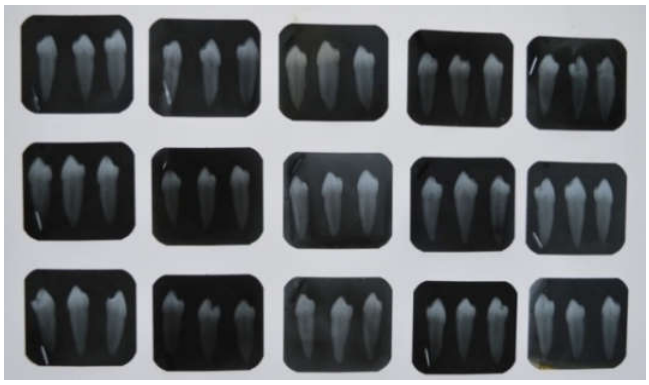


Figure 2. Mesio-Distal radiodraphs of specimens

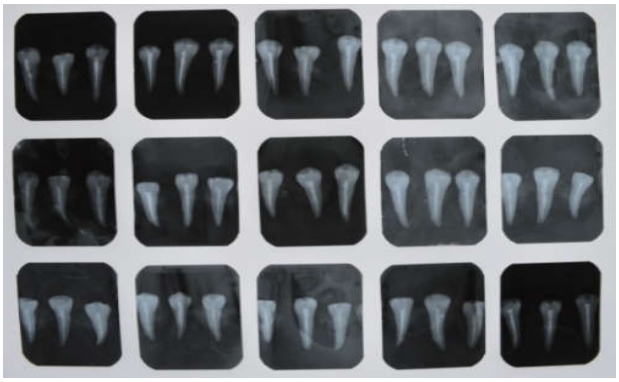


Figure 3. Mesio-Distal radiographs of obturated teeth

Figure 4. Bucco-Lingual radiographs of obturated teeth

Figure 5. Group I specimens

Figure 6. Group II specimens

Figure 7. Group III specimens

Figure 8. Group IV specimens

Figure 9: Retreatment with Hedstrom files

Figure 10: Retreatment with K3 files

Figure 11: Retreatment with Pro Taper Universal Retreatment files

motion to remove gutta-percha and sealer from the canal until the working length was achieved with size 30 H-file (Fig. 9). A step-back procedure with H-files was then completed coronally in 1-mm increments to file size 50.

Group III- Gutta-percha removal with K3 files

Canals were retreated with K3 files in Anthogyr gear reduction hand piece in a crown down technique at 500 rpm using a gentle in-and-out motion (Fig. 10). Very light pressure was applied. In case the rotary file would not go deeper, K file was used to establish a glide path before the rotary instrument was reintroduced. File sequences were used as follows: size 25 (0.06 taper) was used at one-half of the working length; size 20 (0.06 taper) was used between one-half and two-thirds of the working length; and instruments of sizes 20 (0.04 taper), 25 (0.04 taper), and 30 (0.04 taper) were used to reach the working length.

Group IV- Gutta-percha removal with Protaper Universal Retreatment files

Gutta percha was removed with ProTaper Universal Retreatment system in Anthogyr gear reduction hand piece at 500 rpm in a crown-down manner. D1 (0.09/0.30 mm), D2 (0.08/ 0.25 mm) and D3 (0.07/0.20 mm) were sequentially used in a brushing motion circumferentially with lateral pressing movements to reach the pre-established WL; D1 was used to remove gutta percha from the coronal third. D2 & D3 were used to remove gutta percha from middle and apical third of the root canal respectively (Fig. 11). If the rotary instruments would not advance in the canal, stainless steel K files were used to establish a glide path before reintroducing the rotary instruments. All the instruments were used in three root canals and then discarded. Also, any deformed instruments were discarded. Retreatment was deemed complete when no additional gutta-percha or sealer was visible on the files, and the canal walls were smooth as verified with K-files. If these requirements were not met, the canals were further instrumented with the last file used until the criteria were fulfilled. Each root canal was prepared, filled, and retreated by the same operator to reduce inter operator variability.

Evaluation: On completion of retreatment procedure, the Eppendorf tubes were removed from the vials. The root apex was washed with 0.2 ml of distilled water to collect the debris adhering to the external surface of the apex into the tube. The Eppendorf tubes were stored in an Incubator (Rotek, Sl no 99041) at 37 ºC for 21 days to evaporate the irrigant before weighing the dry debris (Fig. 12). The tubes with the dried debris were weighed using the Analytical balance (Fig. 13). Three consecutive measurements were taken for each tube, and the mean value was recorded. The weight of the extruded debris was determined by subtracting the weight of the pre-weighted empty Eppendorf tubes from the weight of the tubes with the dried debris. Weight of extruded debris=Weight of Eppendorf tube with dried debris MINUS Pre-weighted weight of empty Eppendorf tube.

RESULTS

Observations were statistically analyzed using Analysis of Variance (One way ANOVA) to evaluate the difference among four groups, followed by Students 't' test for Pair wise comparision. 'P' value of <0.05 was considered for statistical significance. In Group I, where no retreatment was done, there was no debris extrusion apically. In Group II, where retreatment was done with H-files, the mean amount of debris extruded apically was 0.0025 gms. This was statistically significant when compared with other groups indicating that H-files extruded greater amount of debris than K3 and PTUR files. In Group III, where retreatment was done with K3 files, mean debris extrusion was 0.0010gms which was significantly less than H-files, but no statistically significant difference was seen with PTUR files. In Group IV, PTUR files showed mean amount of debris extrusion of 0.0008gms which was significantly less when compared with H-files but was not significantly different with the mean extrusion value of K3 files (Table 1). Overall analysis of the results states that maximum Debris extrusion is seen in Group II (retreatment done with H-files) and minimum Debris is seen in Group I (Control group). Retreatment with manual H-files extruded statistically more debris when compared to rotary NiTi files - K3 and PTUR files. There was no statistical significant difference of debris extruded between rotary K3 and PTUR files (Table 2). Graph 1 represents the mean values of all groups tabulated in Table1. Graph 2 represents the pair wise comparision of mean values tabulated in Table 2.

DISCUSSION

The main goal of Endodontic retreatment is to achieve the decontamination of the root canal system in order to establish healthy periapical tissues and allow tissue repair. Thus, nonsurgical retreatment aims to completely remove the root filling, thus facilitating effective cleaning, shaping and filling of the root canal system. Removing as much sealer and gutta-percha as possible from an inadequately prepared and filled root canal system is crucial to uncover remnants of necrotic tissue or bacteria that may be responsible for periapical inflammation and failure (Imura *et al.,* 2000). When Endodontic retreatment is performed, irritants in the form of filling materials, necrotic material, bacteria, or irrigants are introduced into the apical lesion. The apically extruded materials are held clinically responsible for postoperative pain, inflammation, flare-ups or even failure of apical healing (Seltzer *et al.,* 1985; Siqueira *et al.,* 2003; Tinaz *et al.,* 2005). The type of tooth utilized plays a very important role. In previous studies, (Reddy and Hicks *et al.,* 1998) have used single-rooted mandibular premolars (Myers and Montgomery *et al.,*1991) single-rooted maxillary lateral incisors and mandibular premolars (Ferraz *et al.,* 2001) maxillary and mandibular central and lateral incisors with single canals (Huang *et al.,* 2007) maxillary anterior teeth and (Saad *et al.,* 2007) single-rooted anterior teeth and premolars. In the present study, only single-rooted mandibular first premolars with single straight canal were used, because application of one kind of tooth can help increase the similarity among specimens and they are extracted commonly for orthodontic treatment. Thus, the results are valid only for teeth with fully formed apices and straight canals. Unfortunately, in vitro studies do not fully reproduce in vivo conditions, and decoronation further reduces their clinical relevance. Therefore in this present study, the teeth were not decoronated, but to assure standardization of specimens the length of filling material was uniformly limited to 16mm from the apex to the coronal aspect. The results of the present study showed all the instrumentation techniques caused apical extrusion of debris.

Figure 12. Incubator

Figure 13. Analytical balance

Table 1. One way ANOVA demonstrating Mean, Standard Deviation and Statistical significance among four groups

Groups	Post weighed-Pre weighed	Post weighed-Pre weighed	F Value	P Value
	MEAN	SD		
Group I	0.0001	0.0000	60.800	<0.001
Group II	0.0025	0.0025		Significant
Group III	0.0010	0.0025		
Group IV	0.0008	0.0025		

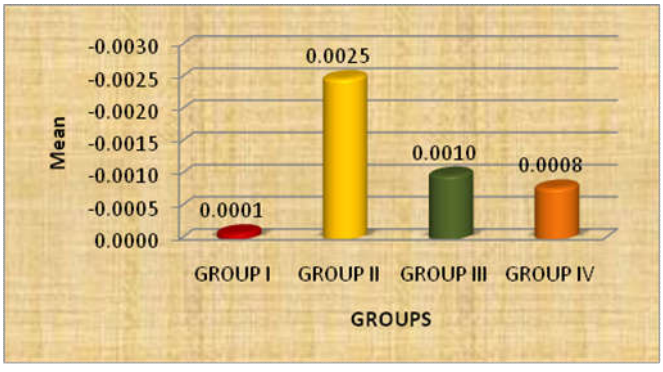
Statistical Analysis: ANOVA one way test. Statistically significant if P<0.05

Table 2. Pair wise comparision of Mean, Standard Deviation & Statistical significance among four groups

Groups	MEAN (Post weighed-Pre weighed)	SD (Post weighed-Pre weighed)	t value	P value
Group I	0.0001	0.0000	10.450	<0.001
Group II	0.0025	0.0025		Significant
Group I	0.0001	0.0000	8.616	<0.001
Group III	0.0010	0.0025		Significant
Group I	0.0001	0.0000	8.916	<0.001
Group IV	0.0008	0.0025		Significant
Group II	0.0025	0.0025	6.113	<0.001
Group III	0.0010	0.0025		Significant
Group II	0.0025	0.0025	7.111	<0.001
Group IV	0.0008	0.0025		Significant
Group III	0.0010	0.0025	1.518	0.140
Group IV	0.0008	0.0025		Not Significant

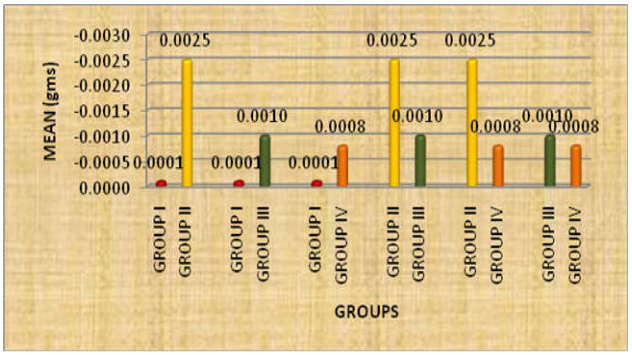
Statistical Analysis: Unpaired t test. Statistically significant if P<0.05

The extrusion produced was expected, as it is considered a problem with all instrumentation techniques (Vande Visse *et al.,* 1975). In Group I, where no retreatment was done, there was no debris extrusion apically.



Graph 1. Graphical representation of Mean values of different groups in terms of Debris extrusion

In Group II, where retreatment was done with Hedstrom files, the mean amount of debris extruded apically was 0.0025 gms. This was statistically significant when compared with other groups indicating that H-files extruded greater amount of debris than K3 and PTUR files.



Graph 2. Pair wise comparision of Mean value of Debris extrusion

Greater amount of material extruded by the hand filing/solvent technique occurred probably due to the filing motion used. The push-pull filing action of the instrument may act as a piston, pumping the irrigating solution and the debris through the apex as less space is available to flush it out coronally. This is in accordance with studies done by (Al Omari *et al.,* 1995*;* Mangalam *et al.,* 2002). In Group III, where retreatment was done with K3 files, mean debris extrusion was 0.0010gms which was significantly less than H-files, but no statistically significant difference was seen with PTUR files. K3 rotary NiTi instrument used in this study was reported to have a slightly positive rake angle in combination with a radial land relief. A positive rake angle tends to increase the cutting efficiency of the file (Bergmans *et al.,* 2001). Therefore, K3 could remove the gutta percha in large pieces around the spirals of instruments, whereas H-files only removed gutta-percha in small increments. The apically directed force used to facilitate file penetration may have contributed to the minimal debris extrusion noted. This is in accordance to with the studies done by (Saad *et al.,* 2007; Alper Kustarci *et al.,* 2012). In Group IV, Pro Taper Universal Retreatment files showed mean amount of debris extrusion of 0.0008gms which was significantly less when compared with H-files but was not significantly different with the mean extrusion value of K3 files. PTUR files could remove gutta-percha from the canals in large pieces around the spirals of instruments, where as Hedstrom files removed gutta-percha only in small increments (Huang *et al.,* 2007). The better performance is probably attributed to the unique instrument design. D1, D2, and D3 have 3 progressive tapers and lengths, which fit the coronal, middle, and apical portions of the canal, respectively (Gu *et al.,* 2008).

Moreover, the ProTaper files have a convex triangular cross section that reduces the area of contact between the instrument and the dentin walls. The negative cutting angles and the absence of radial land might permit a cutting action rather than a planning action. This is in accordance to with the studies done by (Huang *et al.,* 2007; Sowmya Shetty *et al.,* 2014). Lu *et al.,* 2013 compared the amount of apically extruded debris and irrigant produced by two Ni-Ti instruments and hand files when removing root fillings. The teeth were randomly divided into three groups of 20 for removal of the root filling material with Reciproc files (Group 1, RP), Mtwo retreatment files (Group 2, MR) or hand files (Group 3, Hedstrom). Results showed that removal of root fillings with two Ni-Ti instruments produced less apically extruded debris and irrigant than hand Hedstrom files. Alper Kustarci *et al.,* 2012 compared the amount of debris apically extruded during endodontic retreatment using two rotary nickel titanium (NiTi) instruments (K3 and R-Endo) and Hedstrom files. They concluded all retreatment techniques produced extruded debris during endodontic retreatment; however, both rotary NiTi systems were associated with less apical extrusion than manual instrumentation with Hedstrom files. Transferring the present results to the clinical situation should be done with caution due to the absence of a physical back-pressure provided by the periapical tissues. Also, periradicular tissue pressure that exceeds intra-canal pressure could limit the amount of extruded debris (Fairbourn *et al.,* 1987).

The study methodology did not resemble a closed system. The experimental set-up presented no back-pressure, and gravity may have influenced the extrusion of irrigant and debris out of the canal. This shortcoming of this laboratory model has already been discussed by Myers & Montgomery *et al.,* 1991 and in a recent study, which was conducted by Burklein & Schafer *et al.,* 2012 under identical experimental conditions. A simulation of back-pressure of the periapical tissues by using floral foam has been proposed by Altundasar *et al.,* 2001 and Hachmeister *et al.,* 2002, but this set-up suffers from several disadvantages such as absorption of irrigant and debris. Hence, no attempt has been made in the present study to simulate periapical resistance.

Conclusion

Within the limitations of the study, it is concluded that all retreatment techniques resulted in debris extrusion during Endodontic retreatment. Retreatment with manual H-files resulted in significantly greater extrusion of debris. Use of Engine – driven NiTi instrumentation techniques (K3, PTUR files) for retreatment significantly reduced the apical extrusion of debris.

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