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The Amount of Extruded Debris: (An In-vitro Comparative Study)

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Abstract

Background Debris including dentin chips, residual pulp tissue, microorganisms and irrigants can be forced towards the periapical area. This extrusion may cause discomfort, pain, persistent inflammation and inter appointment flare up. **Objectives** To measure and compare the amount of apically extruded debris by using five irrigation techniques. **Materials and Methods** Seventy-five palatal root of extracted maxillary first molars were used. Each root was mounted in the pre-weighed collecting glass vial. The samples were randomly divided into five groups of 15 samples for each group according to the used irrigation technique: (Needle irrigation, Passive Ultrasonic Irrigation by NSK Varios, sonic irrigation by EndoActivatr, CanalBrush and EndoVac irrigation system). Canals were prepared using ProTaper NEXT rotary NiTi files to size X4, the irrigation technique of each group was conducted according to manufacturer instructions. The difference between pre and post-instrumentation weights presented as the weight of extruded debris. **Results** Showed that all irrigation techniques caused apical extrusion of debris with different values.
Conclusion EndoVac was found to be the safest irrigation system among all groups with respect to apical extrusion of debris.

Keywords: Apically extruded debris; CanalBrush; EndoVac; EndoActivator; Irrigation

Introduction

Chemomechanical debridement of root canals is an essential part of endodontic therapy. The aims of this phase of treatment are elimination of organic and inorganic debris by using instruments and endodontic irrigants (Leonardi et al, 2007). Irrigation is an important cornerstone of a successful endodontic treatment because it allows for cleaning beyond what instrumentation can achieve alone (Gu et al, 2009). It has been demonstrated that during root canal instrumentation and irrigation, debris including dentin chips, residual pulp tissue, microorganisms and irrigants can be forced towards the periapical area (Pranav and Van, 2009). This extrusion may cause discomfort, pain, persistent inflammation and interappointment flare up (Tanalp and Gungo, 2014). Irrigants are often delivered with a 30 or 27-gague endodontic needle placed into the canal until just short of the binding point (Mitchell et al, 2010). Passive ultrasonic irrigation (PUI) of root canals has been suggested to improve canal debridement and disinfection, PUI operates at frequencies range (25-40 kHz) (Van der Sluis et al, 2007). EndoActivator (Dentsply, Switzerland) is a sonic irrigants agitation system that operates at frequencies range (1-10 KHz) was developed to effectively remove debris from lateral canals and eliminate the smear layer (David et al, 2010). While CanalBrush (Coltene, Germany) is highly flexible polypropylene endodontic microbrush, which designed to remove canal debris effectively (Gu et al, 2009; Yildiz et al, 2010). The EndoVac (Kerr, USA) irrigation system with apical negative pressure was developed to address the procedural difficulty of delivering irrigants safely to the working length with less extrusion (Nielsen et al, 2007). The type of irrigation system, needle tip design as well as needle placement depth influences the flow pattern and apical wall pressure, which are important factors affecting irrigation effectiveness and safety. Accordingly, it would highly benefit for the patient to choose an irrigation system that minimizes the risk of extrusion into the periapical tissues (Pranav and Van, 2009; Shaimaa and Heba, 2016). Hence, this study was designed for evaluating the amount of apically extruded debris using five irrigation techniques (Needle irrigation, Passive Ultrasonic Irrigation, EndoActivator, CanalBrush and EndoVac).

Materials and Methods

Samples collection and preparation

Seventy-five freshly extracted maxillary first molars with straight and mature palatal root had been used in the present study. The external surface of teeth was cleaned using periodontal cumine, then the presence of any visible cracks or fracture was verified with the use of magnifying eye lens and light cure device. The palatal root of each tooth was sectioned to a uniform length of 12 mm. The pulpal tissue was removed using barbed broach #10. Apical patency of canals was ensured by insertion a #10 hand K-file into the canal and advancing until it was visualized at the apical foramen. Working length was obtained by subtracting 1mm from the actual length of the root. Single canal and apical foramen, this was determined by taking digital radiographs in buccolingually and mesiodistal directions. The samples then had been randomly divided into five groups (15 samples for each group) according to the type of irrigation technique that was used to irrigate the root canals.

Sample fixation and debris collection

The procedure for collection the extruded debris was carried out similar to that described by Myers and Montgomery in 1991 (Myers and Montgomery, 1991) in which seventy-five collecting glass vial with the rubber stopper were used for collecting the extruded debris. All vials were coded numerically according to the irrigation system used for each group, then each vial was weighed without the rubber stopper using the sensitive electrical balance (0.00001) (Kern-ABT 100-5M, Germany). This recorded weight represented the pre-instrumentation weight. A glass container (Beaker) was placed in the central hole of a specially designed squared wood base to provide fixation to the glass container, and each vials were then positioned inside the glass container, to facilitate holding the vial and to prevent any debris from environment to accumulate during working. Each root was forced into a hole made in the center of rubber stopper except for the coronal portion. And then the stopper/root complex were fixed to the pre-weighed vial, in which the middle and apical part of the root inside the vial. A rubber dam sheet had been used to coat the outer surface of the glass container. A bent needle (gauge-23) was introduced through the rubber dam and stopper beside the root to equalize the pressure between the inner and outer sides of the vial (Figure 1).

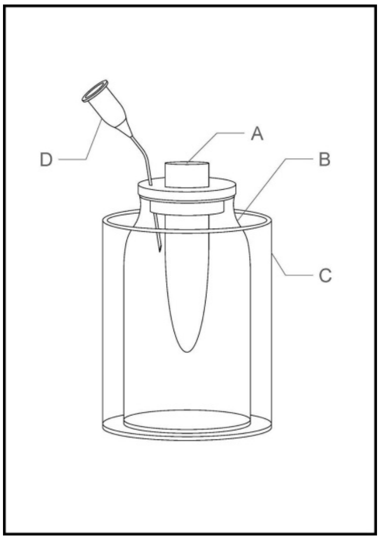

Figure (1): Drawing illustration of the collecting apparatus: (A) Root, (B) collecting glass vial, (C) Glass container, (D) Ventilating needle.

Root canal instrumentation: Root canals preparation was done with ProTaper NEXT rotary NiTi files (Dentsply Maillefer, Switzerland) in a crown-down technique with brushing motion until reaching X4 (40/06) according to the instructions of the manufacturer at constant speed (300 rpm) and torque (4.0 Ncm). Root canals irrigation: In order to control the amount of pressure during delivering the irrigants, Auto Syringe (Vista.USA) set at medium speed (flow rate 2.5 mL/min) had been used for canal irrigation with a (30-gauge) closed end side-vented irrigation needle, each time the needle tip was placed into the root canal until just short of the binding point, but no closer than 2mm to the working length. For each sample, 1 mL of distilled water (D.W) was used for irrigation after each file and following the use of the last file, 2 mL of D.W was used to complete the irrigation process. The total amount of irrigating solution was 6 mL of distilled water. Group I: (Needle irrigation using side-vented needle): After completion of canal instrumentation, the samples of this group received 2 mL of distilled water using Auto Syringe with (30-gauge) side-vented endodontic irrigation needle without any agitation of irrigants. Group II: Passive Ultrasonic Irrigation by the NSK Varios: After completion of canal instrumentation, a Piezoelectric Ultrasonic unit (NSK Varios 570 iPiezo Engine, Japan) was used to subject the root canals of this group to PUI with the aid of a stainless steel ultrasonic file corresponding to 25 ISO size. PUI was done by dividing 1 mL of distilled water into 3 equal parts. After delivering each part, it was activated by passively moving the oscillating ultrasonic file for 20 seconds at 1 mm shorter than the working length (the total period was 60 seconds). The canal then received 1 mL of distilled water as a final rinse. Group III: Sonic Irrigation by the EndoActivator: After irrigating the canal with 1.0 mL D.W, the EndoActivator (Dentsply Maillefer, Switzerland) with a medium-size polymer tip (corresponding to number 25 ISO size) was inserted passively inside the root canal, placed 2mm shorter than the working length, and then activated at 10,000 cpm. The activation of irrigant was done using pumping action in short 2-3mm vertical strokes for a period of 60 seconds. The canal then received 1 mL of distilled water as a final rinse. Group IV (Canal Brush): The instrumented

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canals had received 1.0 mL D.W, then a medium-size Canal Brush (Coltene, Germany) corresponding to number 30 ISO size was placed in Endo-Mate TC2 motor (at speed of 600 rpm) and used to activate the irrigant at 1 mm shorter than the working length. The canal was brushed in a circumferential motion with a gentle 2-3 mm up and down movement for a period of 60 seconds. The canal then received 1 mL of distilled water as a final rinse. Group V (EndoVac irrigation system): After each used file, the canal was irrigated with 1 mL of distilled water using the Master Delivery Tip (MDT) installed onto Auto Syringe that hold the irrigants solution, as follows: First, the MDT was used to deliver 0.5 mL of irrigants. At the same time, the MDT was placed at the access, the Macro Cannula was placed inside the canal to 4 mm from WL and worked up and down rapidly to help flush evacuate the irrigant from the coronal and middle thirds of the canal. Finally, the MDT was returned to continue irrigating the canal with the second 0.5 mL of irrigants while placing the Micro Cannula inside the canal at 2 mm from the WL for 6 seconds. Then, it was moved down to WL and held in position for other 6 seconds, to help flush evacuate the irrigants from the apical third of the canal. Then, each sample received 2 mL of D.W. as a final rinse using the same protocol. Collection and weighing of extruded debris: Once canals irrigation had been completed, the rubber-stopper/root assembly was separated from the vials. Then, the apex of the root was flushed with 1.0 mL of distilled water to wash and collect any adherent debris into the vial. Subsequently, the vials were placed in a dry heat oven at 100°C until the distilled water was completely evaporated. The vials were then kept in closed desiccator containing calcium chloride for 24 hours to absorb any remaining moisture. After that, each vial was re-weighed by using an electronic balance to obtain the final weight of the vial containing the extruded debris; this value represented the post-instrumentation weight (Figure 2). The weight of extruded debris was then calculated by subtracting the pre-instrumentation weight from the post-instrumentation weight of each collecting vial. The amount of extruded debris was analyzed statistically using the One-way analysis of variance test (ANOVA) and Tukey's post hoc test for multiple comparisons at a significance level of p 0<0.05.

Figure (2): Weighing of the vials using sensitive electronic balance.

Results

The results of this study revealed that all groups induced extrusion of debris from the apical foramen but with different values. Table (1) showed the mean, minimum, maximum values and the standard deviation of each experimental group. EndoVac group (V) showed the lowest mean value of apically extruded debris in comparison with other groups, followed by Needle irrigation (I), EndoActivator (III) and Canal-

Brush (IV) groups respectively. While passive ultrasonic irrigation group (III) has showed the highest mean value. Tukey's post hoc test results showed that group I (Needle irrigation) had no significant difference with group III (EndoActivator) (P 0>0.05).

Table (1): Descriptive statistics of apically extruded debris for all groups.

Group	Min.	Max.	Mean	SD
I	0.12	0.58	0.3100	0.14233
II	0.59	1.11	0.8227	0.17090
III	0.24	0.61	0.3847	0.10260
IV	0.39	0.74	0.5447	0.12212
V	0.03	0.16	0.0753	0.04155
Total	0.03	1.11	0.4275	0.27793

Table (2): Analysis of Variance (ANOVA) test for mean of AED for all groups.

	Sum of Squares (ss)	df	Mean Square	F	P-value	Sig.
Between Groups	4.643	4	1.161	75.741	0.000	S
Within Groups	1.073	70	0.015			
Total	5.716	74				

Discussion

When performing an endodontic treatment, irritants might be introduced into the periapical area. Extrusion of these infected debris and irrigants apically are associated with postoperative complications such as inflammation, delay of healing of periapical tissue and pain (Fatih et al, 2016), and considered to have a large influence on the failure of the treatment procedure (Dragana et al, 2018). Therefore, a reduction of extruded debris is desirable to reduce postoperative flare-ups. The present study revealed that all of the irrigation techniques caused apical extrusion of debris with different values. The results were consistent with previous studies, which demonstrated that no method could completely inhibit debris extrusion. (Varsha et al, 2013; Psimma et al, 2013; Emre et al, 2015). The present study showed that EndoVac irrigation system extruded apically the lowest mean value of debris when compared to other four groups, and this result is in agreement with (Varsha et al, 2013; Jatin et al, 2014; Karatas et al, 2015). The reason could be related to that EndoVac is based on negative apical pressure. According to the design of EndoVac system, it uses a couple of macro and micro cannula to deliver the irrigants all the way down to the working length of the canal and then evacuate it by the negative pressure of the suction unit, makes it possible to irrigate root canal up to the working length safely without extrusion of irrigants beyond the apical foramen of the canal (Benjamin and Craig, 2007; Varsha et al, 2013). According to this study, the results showed that Group II (PUI) had the highest mean value of apically extruded debris when compared to other four groups, and this result is in agreement with previous studies (Varsha et al, 2013, Jatin et al, 2014). This might be related to that the PUI creates cavitation and acoustic microstreaming of the irrigants. Active streaming enhances the irrigants to contact a greater surface area of the canal wall. Thus, improve the potential of debris removal from canal that may cause more extrusion. Additionally, tip of ultrasonically activated file was placed 1 mm shorter than the working length that create a turbulence of irrigants in the apical third, causing more extrusion in the present study. Group III (EndoActivator) in the present study extruded significantly less than passive ultrasonic irrigation, and this result is consistent with previous studies (Pranav and Van, 2009; Jatin et al, 2014). This might be related to two reasons. First, sonic irrigation works at a lower frequency, the frequencies for sonic application ranges from 1 to 10 KHz, while the frequencies for ultrasonic application ranges from 25 to 40 kHz. Second reason, the oscillating patterns of the sonic instrument is different; it produces purely acoustic microstreaming without cavitation (Ricardo et al, 2014) leading to reduce the debris removal from the canal walls and which in turn may cause a reduced amount of apical extrusion (Nair et al, 2011). The present study showed that Group I (needle without activation of irrigants) extruded less debris than PUI and Canal brush. This result is in agreement with earlier study (Shaimaa and Heba, 2013). While the mean value of apically extruded debris for Group I and Group III (EndoActivator) were almost equal (p 0> 0.05) (statically not significant difference), and this may be due to that in Group I, the absence of irrigants agitation inside root canal using mechanically driven instruments resulted in deficiency of turbulence of fluid in the apical third that may cause to force debris from the apical foramen. The current study showed that the mean values of AED for CanalBrush was significantly less than PUA and significantly more than EndoVac group and this finding is in accordance with the results of a previous study (Jatin et al, 2014). This may be explained by the action of CanalBrush which is based on centrifugal force and rotated clockwise at high speed and only 1mm shorter than the working length. Different factors may affect the amount of extruded debris such as: the technique of instrumentation and irrigation, type of instrument used for canal shaping, type and amount of irrigating solution, size of apical stop, preparation endpoint and the presence of more than one canal. (Varsha et al, 2013; Burklein et al, 2013). For this reason, the samples for this study were carefully selected, all teeth had mature apex, patent apical foramen, and had a standard initial size file which was #20 K file. Also, canal instrumentation was accomplished in the same manner in all groups; the W.L was kept 1 mm short of the apical foramen. Studies revealed that when instrumentation was performed 1 mm shorter than the canal length, it would result in a significantly less extrusion of debris than when it was performed the apical foramen (Fukumoto et al, 2006; Varsha et al, 2013). The irrigants solution that had been used in the present study was distilled water for two reasons. First, the type of the irrigation material affects the amount of extruded debris, and 5.25% NaOCl had the greatest amount of debris followed by 2.5% NaOCl then CHX (Parirokh et al, 2012). Second reason, when sodium hypochlorite irrigants get dehydrated, it would result in the formation of salt crystals that cannot be isolated from cutting debris which would increase the weight of extruded debris (Burklein et al, 2013). In addition, safe-tip (closed-end) needles had been used during irrigation, since the open-end needles produced more extrusion (Gu et al, 2009). The depth of placement of the needle tip in this study was 2 mm short of the full W.L since extrusion is decrease when the needle moved away from apical foramen (Psimma et al, 2013). To achieve standardization and to minimize the variables during the course of the present study steps, all works had been completed by the same operator (the researcher). It must be highlighted that the results of in vitro study cannot be directly generalized to the clinical situation, because of the absence of periapical tissues and bone that work as a natural barrier against extrusion of debris and irrigants. But the used methodology of the present study had been received the utmost attention and implemented by several studies associated with apically extruded debris.

Conclusion According to the proposed methodology and results of this in vitro study it was concluded that all irrigation techniques extruded debris beyond the apical foramen. The EndoVac irrigation system showed the lowest mean value of AED. While the PUI showed the highest value of apically extruded debris.

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