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Comparison of Apical Debris Extrusion Using EDDY, EndoActivator, Ultrasonic Irrigation and Manual Dynamic Agitation

EDDY, Endoaktivatör, Ultrasonik İrrigasyon ve Manuel Dinamik Aktivasyonun Apikalden Çıkan Debris Miktarına Etkisi

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ABSTRACT

Objective: This study was aimed to determine the amount of apically extruded debris using different final irrigation activation techniques.

Methods: The mesial roots of 70 extracted mandibular molar teeth were included. The mesiobuccal roots were instrumented to size 40/.06 with a reciprocal system file and divided into five groups according to the final irrigation activation technique used: EDDY, EndoActivator (EA), passive ultrasonic irrigation (PUI), manual dynamic agitation (MDA) or needle irrigation (NI). The extruded debris was collected in Eppendorf tubes and stored in an incubator at 70°C for 5 days. The results were analysed using the Kruskal–Wallis test (P=.05).

Results: EDDY and the EA caused significantly more apical debris extrusion (P < .05). There were no statistically significant differences between EDDY and the EA (P > .05). NI caused less extrusion, but there were no statistically significant differences between PUI, MDA and NI (P > .05).

Conclusion: EDDY and the EA were associated with significantly higher apical extrusion debris extrusion.

Keywords: debris extrusion, EDDY, Endoactivator, irrigation activation, manual dynamic agitation, ultrasonic irrigation.

ÖZ

Amaç: Bu çalışmanın amacı, farklı irrigasyon aktivasyon tekniklerinin apikalden ekstrüze olan debris miktarına etkisini incelemektir.

Yöntemler: Yetmiş adet çekilmiş mandibular molar dişin mesial kökleri çalışmaya dahil edildi. Mesiobukkal kökler, resiprokal hareketle çalışan eğe sistemi ile 40/.06 boyutunda prepare edildi ve final irrigasyon aktivasyon tekniklerine göre beş gruba ayrıldı: EDDY, Endoaktivatör (EA), ultrasonik irrigasyon (UI), manuel dinamik aktivasyon (MDA) ve iğneli irrigasyon (NI). Ekstrüze debris Eppendorf tüplerine toplandı ve eppendorf tüpleri beş gün boyunca 70 °C'de bir inkübatörde bekletildi. İstatistiksel analiz için Kruskal-Wallis testi kullanıldı. (P = ,05).

Bulgular: EDDY ve EA, diğer aktivasyon tekniklerine göre önemli ölçüde daha fazla debris ekstrüzyonuna neden oldu (P < ,05). EDDY ve EA arasında istatistiksel olarak anlamlı bir fark yoktu (P > ,05). En az debris ekstrüzyonu NI'da gözlendi ancak PUI, MDA ve NI arasında istatistiksel bir fark yoktu (P > ,05).

Sonuç: EDDY ve EA, diğer gruplara göre daha yüksek derecede apikal debris ekstrüzyonuna neden oldu.

Anahtar Kelimeler: debris ektrüzyonu, EDDY, Endoaktivatör, irrigasyon aktivasyonu, manuel dinamik aktivasyon, ultrasonic irrigasyon.

INTRODUCTION

The success of root canal treatment depends on the effective elimination of microorganisms and byproducts from the root canal system. Despite the development of endodontic instruments for this task, it is known that mechanical preparation is still not sufficient for root canal cleaning. It has been shown that untouched areas remain on the root canal surface when mechanical preparation is used on its own.[1] Needle irrigation (NI) is the basic technique for root canal irrigation, and the level of needle tip placementin the canal is the most dominating factor for solution extrusion.[2] NI does not provide adequate disinfection, especially in the apical third of the root. Therefore, activation of the irrigating agent has been recommended for effective root canal irrigation.[3]

During the irrigation activation procedure, residual tissues, bacteria and byproducts within the canal may extrude through the apical foramen into the periradicular area. This is an undesirable situation and is considered the main cause of postoperative pain following endodontic treatment.[4] For this reason, selecting an irrigation activation procedure that can reduce the risk of debris extrusion is important for postoperative pain.[5]

Passive ultrasonic irrigation (PUI) cleans dentin through acoustic streaming and cavitation.[6] It has been shown that increased fluid dynamics results in greater penetration of the irrigation solution and removal of the smear layer, especially in the apical third and untouched areas of the root.[7,8] Manual dynamic agitation (MDA) is performed by moving a gutta-percha main thread compatible with the preformed canal up and down in the canal with short, gentle strokes of 2 to 3 mm. An effective hydrodynamic effect can be produced with this technique.[9]

The EndoActivator (EA, Medium, Dentsply Sirona), a sonically powered canal irrigation system, is a portable handpiece with disposable flexible polymer tips in various sizes that do not sever root dentin.[10] It was shown that this technique can thoroughly debride the complex root canal anatomy and remove the smear layer and biofilm.[11] EDDY (VDW, Munich, Germany), another sonic device with a non- cutting disposable polyamide tip (#25, taper 0.04), is powered by an air scaler at a rate of approximately 6,000 Hz.[12] The disposable non-cutting tip moves in three dimensions and enhances the cavitation and acoustic flow effect of the irrigation solution through high-amplitude oscillation.[13]

Previous studies have shown that irrigation techniques and file systems can cause apical debris extrusion, depending on the type of technique and the kinematics of the files.[14,15] However, there are no studies comparing the effects of EDDY, EA, PUI, MDA and NI on apical debris extrusion. Therefore, the purpose of this experimental study was to compare the effects on apical debris extrusion of EDDY, the EA, PUI, MDA and NI. The null hypothesis was that altering the irrigation activation techniques used would not affect the amount extruded.

METHODS

Tooth Selection

This study was conducted according to the Preferred Reporting Items for Laboratory studies (PRILE) 2021 guidelines.[16] The study was approved by The Ethics Committee of the Faculty of Dentistry, Atatürk University (Decision Date/Number: 26.01.2022 / 2022-03-22). Extracted mandibular molars were obtained from surgeries undertaken to address periodontal or orthodontic issues. All teeth had two different apical foramens with two mesial canals. Roots with apical diameters greater than the #15K file size were not included. Teeth with calcification, crack formation or resorption were also excluded. The curvature of each root canal was determined according to the Schneider method using digital radiographs which were taken in buccolingual and mesiodistal directions.[17] The mesial roots of 70 mandibular molars with canal curvatures ranging from 10 to 20 degrees were included. An access cavity was prepared, and a #10K file (Dentsply, Sirona, Switzerland) was placed until it was visible through the apical foramen. Glide path preparation was performed with a ProGlider (#0.16) rotary file according to manufacturer recommendation (300 rpm / 2 Ncm). Working length was determined by subtracting 0.5 mm from this length. The mesial roots of the teeth were removed from the cementoenamel junction. The working length (WL) was then standardised to 16 mm.

According to power analysis software (G*Power 3.1.Universitat, Düsseldorf, Germany), the sample size of 11 samples per group was determined from a previous study at an alpha error probability of 0.05 and power of 95% (effect size = 0.642).[18] To enhance the statistical power of the study, 14 teeth were enrolled in each group. The specimens were numbered and randomly allocated to four groups (n = 14) using a web programme (www.randomizer.org).

Myers and Montgomery's[19] method was followed to carry out the experimental procedures. Eppendorf tubes were preweighed three times on a 10^{-4} precision scale (Precisa XB 220A, Precisa Instruments, Dietikon, Switzerland), and the average weight was recorded as the tube weight. The Eppendorf tubes were placed in glass bottles, and a round hole was created in each of their stoppers. The teeth were inserted into the stopper up to the cementoenamel junction and fixed with cyanoacrylate (Pattex Super Glue; T€urk Henkel, Inc., Istanbul, Turkey) to prevent leakage of the irrigants. A needle was inserted into each stopper to balance the internal and external air pressure, and a rubber dam was used to prevent the operator from observing the root apex during root canal preparation and irrigation. All procedures were performed by the same specialist. The experimental model is as shown in Figure 1.

A Reciproc Silver endodontic motor (VDW, Munich, Germany) was set to 'RECIPROC ALL' mode. Reciproc R25 files (size 25, 0.08 taper; VDW) and R40 files (size 40, 0.06 taper; VDW) were used, and the crown-down shaping procedure was followed. For irrigation during the instrumentation procedures, 2.5 mL of distilled water was used. In the final irrigation, the following irrigation activation protocols with distilled water were applied (n = 14 in each group): EDDY, EA, PUI, MDA and NI.

Experimental Groups

EDDY

The irrigant was activated with a frequency of 6,000 Hz and an amplitude of 160 mm using an air scaler (KaVo SONICflex, KaVo) according to the manufacturer's recommendations. The root canal was filled with distilled water (2 ml). The EDDY's tip was then positioned 2 mm short of the WL, and an up and-down motion was repeated with 5-mm movements for 30 s.

Endoactivator

2 ml of irrigant were filled into the root canal, and the EA's tip (size #25/0.04) was positioned at a distance of 2 mm from the WL. The tip was moved up and-down motion, and the distilled water was agitated for 30 seconds using 5 mm vertical strokes.

Passive Ultrasonic Irrigation

A size 20 Irrisafe tip (Acteon Satelec, France) with a power setting of 3 was mounted on a VDW Ultra ultrasonic device and the irrigant was activated as recommended by the manufacturer with a frequency of 28,000 Hz. Two millilitres of distilled water were filled into the root canal. The tip was positioned two millimetres below the WL, and an up-and-down motion at 5 mm amplitudes was executed for 30 s.

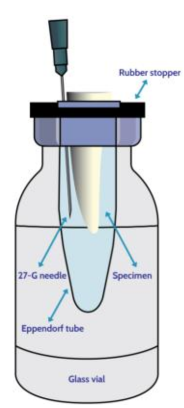

Figure 1. A schematic illustration of the experimental model.

Previous studies have shown that irrigation techniques cause apical debris extrusion

The aim of this study was to compare the efficacy of EDDY, Endoactivator, Passive Ultrasonic Irrigation, Manuel Dynamic Agitation, and Neddle Irrigation in terms of apical debris extrusion

Ethical approval was obtained from The Ethics Committee of the Faculty of Dentistry, University A. (Decision no: 2022-03)

The study includes extracted mandibular molars due to periodontal or orthodontic reasons.

Irrigation protocols were as follows
Group 1 – EDDY (n = 14),
Group 2 - Endoactivator (n = 14),
Group 3 – Passive Ultrasonic Irrigation (n = 14)
Group 4 - Manual Dynamic Agitation (n=14)
Group 5 - Needle Irrigation (n=14)

The apically extruded debris were collected into Eppendorf tubes.

The weight of extruded debris was calculated by subtracting the initial weights of the Eppendorf tubes from the final weights of the tubes.

The results showed that all the activation protocols caused apical debris extrusion. EDDY and EA caused significantly more debris extrusion than the other irrigation activation systems (p<0.05). There were no statistically significantly differences between EDDY and EA (p>0.05). NI caused less apical debris extrusion but there was no statistical difference between PUI, MDA, and NI (p > 0.05).

EDDY and EA using as final irrigation protocols were associated with significantly higher apical debris extrusion.

The authors deny any financial affiliations related to this study.

All authors deny any conflict of interest

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For further details visit: http://pride-endodonticguidelines.org/prile

Figure 2. PRILE 2021 flowchart

Manual Dynamic Agitation

A 2 mL of distilled water was inserted into the canal, and the irrigant was agitated using the MDA approach. A gutta-percha master cone that fit well was placed in the canal and gently moved up and down 100 times in 5 mm strokes for one minute.

Needle Irrigation

A 30 G needle (Ultradent Products Inc) was placed into the canal 2 millimetres short of the WL. Irrigation solution (2 ml) was placed into the root canal, and for 30 seconds, 5 mm movements were used to agitate the distilled water in an up-and-down motion.

All methods of final irrigation activation procedures with distilled water were repeated twice. Following the instrumentation of the root canal, the Eppendorf tubes were taken out of the vials. Each tooth's apex was flushed with 1 mm of distilled water to collect the apically extruded debris that had adhered to the root apex. The Eppendorf tubes were stored in an incubator (Binder, Tuttlingen, Germany) at 70° for 5 days so the irrigant could evaporate. An electronic balance (Precisa XB 220 A) was used to measure the weight of each Eppendorf tube three times. The mean values of extruded debris were recorded. The normality distribution of the data was determined using the Shapiro–Wilk test, and a nonparametric one- way analysis (the Kruskal–Wallis H test) was conducted to compare the amounts of debris. IBM SPSS 22.0 software (IBM, Armonk, NY, USA) was used to analyse the data, with the level of statistical significance set at 0.05.

RESULTS

A PRILE 2021 flowchart is presented in Figure 2. The median, minimum and maximum, and mean rank values are listed in Table 1. The results demonstrate that apical debris extrusion was caused by all the activation protocols tested. EDDY and the EA considerably increased the amount of debris extruded compared to the other irrigation activation methods ($P < .05$). No statistically significantly differences in debris extrusion were observed between EDDY and the EA ($P > .05$). NI caused less extrusion, but there were no significant differences between PUI, MDA and NI ($P > .05$).

Table 1. Different lowercase means significant difference among the groups ($P < .05$).

	n	Median	Min	Max	Mean Rank
EDDY	14^{a}	0,0175	0,0126	0,0308	55,00
Endoactivator	14^{a}	0,0159	0,0122	0,0314	52,43
PUI	14^{b}	0,01	0,0005	0,0234	30,50
MDA	14^{b}	0,0074	0,0002	0,0122	20,54
NI	14^{b}	0,0005	0,0006	0,0129	19,04

DISCUSSION

Although irrigation protocols are essential for successful root canal treatment, increased positive apical pressure can cause extruded debris.[20] In turn, periapical inflammation, postoperative discomfort and flare-ups are caused by apical debris extrusion.[21] There is limited research on differences in apical debris extrusion using of EDDY under various experimental conditions.[22–24] In this study, we investigated the quantity of apical debris extrusion using EDDY, EA, PUI, MDA and NI. The results show that EA and EDDY caused significantly more debris extrusion. Thus, the null hypothesis was rejected.

Ince-Yusufoglu et al.[22] assessed the effects of various irrigation activation systems – EDDY, PUI and PIPS – on debris extrusion and showed that EDDY causes debris extrusion at a statistically significant level. According to a different investigation, PUI produced significantly less apical irrigant pressure than the EDDY technique.[23] Ada et al.[20] investigated debris extrusion using the EA, UI, MDA and NI, and they found that the EA produced the most debris. These results are supported by the present findings. During sonic activation, increasing the flow rate while delivering irrigation chemicals throughout the root canal system improves their efficacy.[25] PUI generate the ultrasonic vibration energy and oscillating movement that allows a lateral flow towards the root canal wall.[6] The 3D motion of the sonic system, along with its frequency and flexible tips, induces a substantial quantity of debris extrusion.[22] This may explain the greater extrusion yielded by EDDY and the EA in the current study.

There was no significant difference in the quantity of debris extruded using the MDA, NI and PUI techniques in the current study. There is no significant difference in the volume of irrigation liquid that extrudes from the apex when using ultrasonic tips rather than conventional needle irrigation when the file is placed 1 or 3 mm beyond the WL.[26] İnce-Yusufoglu et al.[22] reported that PUI caused less apical debris extrusion (by weight) than MI, but there was no statistically significant difference between the amount of debris extruded following MI and PUI application. A previous study comparing the EndoVac, EA, Rispisonic and PUI techniques found that the EA sonic device caused less apical debris extrusion than PUI.[14] Another spectrophotometry-based study that assessed the efficacy of PUI, the EA and MI found that PUI and the EA produced more debris than MI, while no statistical difference was detected between PUI and the EA.[5] Tambe et al.[27] reported that PUI caused less debris extrusion than MI. However, in this study, irrigation solution was activated for 20 seconds. Some methodological factors, such as the using different irrigation solution[14] (such as NaOCl), measurement method of extruded debris[5], agitation time[27] or apical preparation size[23] may have contributed to the inconsistency between previous findings and our results.

The three most popular activation methods are SI, PUI and MDA.[25] İnce-Yusufoğlu et al.[28] examined postoperative pain levels following EDDY and MDA application and recorded statistically significantly higher postoperative pain scores in the EDDY group after 12, 24 and 48 hours. This may be attributed to the inflammation that develops in the periapical tissues as a result of the large amount of debris extruded. The fact that automated techniques produce frequency more efficiently than the manual push–pull action of gutta-percha may account for the difference between MDA and sonic systems.[20]

During the incubation procedure (70°C for 5 days), the irrigants into the canals should be evaporated. If NaOCl or other irrigants was used for irrigation procedures, crystals of these irrigants are likely to remain which might adversely affect the reliability of the study. Sodium crystals that cannot be separated from extruded debris may cause effect of the results.[29,30] Therefore, we used distilled water as the irrigation solution rather than sodium hypochlorite in our study.

Previous research on debris extrusion has focused on floral foam and agar gel techniques.[31,32] It is believed that periapical tissues can be mimicked using these techniques. However, these studies' findings were directly impacted by the foam's absorption of extruded irrigants and challenges in modifying the agar gel's thickness. For this reason, we used Tanalp and Güngör's technique in the current investigation to provide group standardisation.[29]

The use of single and straight roots in this in vitro study was one of its limitations. Karataşlıoğlu et al.[33] reported that the amount of apical debris extruded increases in accordance with the increase in the degree of canal curvature in the teeth. Also, for the real extrusion measurement, it is necessary to use irrigants as in the clinical practice and the periapical tissue resistant must take into consideration. Results may also differ depending on normal or pathological tissues. In clinical applications, in teeth with resorption, perforation defects, or immature roots with open apex, the higher amount of apical extrusion should also be taken into account when using the ajitation techniques with a caustic irrigation agent such as NaOCl or EDTA.[34] The resistance of periapical tissues has an inhibiting effect on apical extrusion of irrigant. Briefly, the observed results should not be generalized to teeth with shorter or longer root length.[35]

CONCLUSION

Within the limitations of this study, using EDDY and the EA as final irrigation protocols produced a significantly higher apical extrusion of debris.

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