Effects of Six Different Irrigation Systems on Potential Apical Extrusion of Irrigants

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Abstract

The purpose of this study was comparing the amount of apically extruded irrigation solutions by using various irrigation systems: Canal CleanMax (CCM), SonicMax, RinsEndo, Passive Ultrasonic irrigation (PUI), Manual Needle Irrigation (MNI), and EndoVac irrigation systems

Sixty single-rooted mandibular premolars were used. ProTaper was used to instrument the canals up to F4 finishing file. Teeth were randomly divided into 6 groups (n = 10). (CCMax, SonicMax, RinsEndo, MNI, PUI and EndoVac). Ten mL final irrigation was made with each irrigation system. Extruded irrigant from the apical foramen was collected into vials. The amount of the extruded irrigation solution was determined by calculating the difference between the initial and final weight of the vials for each group. Results were analyzed by "Kruskal Wallis" and "Conover's multiple comparison" tests.

CCMax and EndoVac groups showed no apical extrusion and these two groups were statistically different from the others significantly (SonicMax, RinsEndo, MNI and PUI systems) ($p < 0.05$), and no difference was found among SonicMax, MNI, Passive PUI systems ($p > 0.05$). Maximum apical extrusion was seen with RinsEndo. RinsEndo showed statistically difference from SonicMax and MNI ($p < 0.05$) but no statistically difference with PUI ($p > 0.05$). The negative pressure irrigation systems (CCMax and EndoVac) were demonstrated to be significantly more successful and safer in terms of apical extrusion.

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Introduction

Removal of vital and necrotic pulp tissues, microorganisms and their toxins from the root canal system is crucial for a successful endodontic treatment.[1] This is accomplished by combining mechanical instrumentation and irrigation.[2,3] Especially in the apical third, ribbon-shaped and oval canals, and in most of the complex anatomical structures (isthmii and anastomosis) cannot be cleaned easily; therefore, microorganisms in the untouched areas can survive.[4,5] Irrigation is one of the most important part of root canal therapy, and irrigation solution should make direct contact with all parts of the canal wall for the most favorable effectiveness.[5] Sometimes irrigation of the root canal system may represent a risk of extrusion of the irrigation solutions into the periapical tissues, causing periapical inflammation and postoperative flare-ups.[6-8]

In modern endodontics, several new techniques and devices for endodontic irrigation were introduced with the purpose of both enhancing the administration of the irrigation throughout the root canals and preventing extrusion of the solutions into the periapex and the related tissues. EndoVac (Discus Dental, Culver City, CA, USA) and Canal CleanMax (CCMax) (Maximum Dental Inc., Secaucus, NJ, USA) were introduced as new irrigation techniques by utilizing a conjoined irrigation and suction systems. The irrigation solution is pushed into the canal to the working length (WL) and suctioned by negative pressure with EndoVac and CCMax. Nielsen and Baumgartner[9] observed that the EndoVac showed no extrusion of the

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solution following the deep intra canal administration and pulling of the irrigation solution from the pulp chamber to the full WL.

The RinsEndo (Dürr Dental GmbH & Co KG, Bietigheim-Bissingen, Germany) is a hydrodynamic root canal irrigation system that irrigates the canal by using the pressure-suction technology. RinsEndo was shown to have higher penetration depth of the irrigant into the root canal dentine when compared to syringe irrigation while representing a higher level of risk of the apical extrusion of the irrigation solution.[10] Manual needle irrigation (MNI), uses a syringe and a needle to deliver the irrigant into the root canal system. Manipulation and control of the needle depth and also the volume of delivered solution is easy with that system.[11] In the Endo-Eze (Ultradent Products Inc, South Jordan, UT), irrigation needle is half-tube in shape and minimizes the risk of positive pressure.

It is known that ultrasound enhances the flushing action of the irrigation.[12] Ultrasonic and sonic energy enhance the efficacy of chemo-mechanical preparation. In Passive ultrasonic irrigation (PUI) method, the file within the root canal does not come into contact with the canal wall. SonicMax is a sonic irrigation system and is powered by a dental unit compressor. It utilizes a small file for irrigation which should be placed in the center of the canal and activated sonically. Sabins et al.[13] observed in their study that passive ultrasonic agitation technique achieved significantly cleaner canals when compared to passive sonic agitation system.

The quantity of extruded irrigation solution beyond the apical foramen to the periapical tissues directly correlates with the device's safety. Even though CCMax and SonicMax have taken a place commercially, to the best of our knowledge, only one paper in the literature has investigated the effect of irrigation.[14] Therefore, aim of this *in vitro* study was to compare potential apical extrusion amount of the irrigation solution using the CCMax, SonicMax, RinsEndo, MNI, PUI, and EndoVac irrigation systems.

Materials and methods

Selection and preparation of teeth

This study was approved by the institution's Reseach Ethics Committee. We used recently extracted sixty single rooted human mandibular premolars with mature apices. Digital radiographs were used to examine the teeth in buccal and proximal directions to verify for a single canal. All teeth had alike root curves of 0-10°. Teeth with calcified canals, open apices or those when the tip of a 15 K-file extruded 1 mm ahead of the apical foramen were rejected. Once debris and soft tissue fragments were cleaned, the teeth were stored in physiological saline solution until required.

Each tooth was decoronated with a diamond disc to create a flat surface. Root lengths were standardized to 18 mm. A size 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was inserted into the canal till noticeable in the apical foramen. The working length (WL) was determined 1 mm short of this length. According to the manufacturer's recommendations, all canals were instrumented using ProTaper (Dentsply-Maillefer Ballaigues, Switzerland) rotary instruments in a crown-down manner (Sequence-S1-Sx-S2-F1-F2-F3-F4). Each canal was prepared with size F4 finishing file. A size 10 K-file was used to check the apical patency among each instrumentation. Between instruments, each canal was irrigated with 1 mL of a 2.5% sodium hypochlorite (NaOCl) solution using a syringe and a 27-gauge needle by placing it down the canal until a slight resistance was felt. A 1 mL of sodium hypochlorite (NaOCl) solution (2.5%) with a syringe and a 27-gauge needle was used to irrigate each canal between instrumentations. Needle was positioned into the canal until a small resistance was felt.

Test setup

Once the root canals were prepared the quantity of solution extruding from the apical foramen during final irrigation by using the method described by Myers and Montgomery.[15] Vials with rubber lid were used. A hole was prepared in the center of the rubber lids using a heated instrument. Each root was inserted with pressure into a rubber lid (apex-down). Isolation was made on the contact surface between the root and rubber lid using dental wax to prevent leakage. The air pressure inside and outside of the vial was balanced by inserting a bent 27 - gauge needle into the rubber lid. The test apparatus was weighed three times using a sensitive scale (Sartorius basic, Sartorius AG, Gottingen, Germany) and the mean measurement was recorded as the initial weight.

Final irrigation

Each root canal was irrigated with 10 mL of 2.5% NaOCl.

The irrigation techniques and apparatus used in this study were as follows:

Group 1 (CCMax) (Maximum Dental Inc., Secaucus, NJ, USA): A 27-gauge needle was placed into the coronal part of the canal and the final irrigation solution was transferred from the coronal part of the root canal by using a 27-gauge needle, the CCMax cannula was placed into the canal closer to the WL. While the cannula was aspirating the irrigation solution, apical-coronal motion (1-2 mm) was applied to the cannula.

Group 2 (SonicMax) (Maximum Dental Inc., Secaucus, NJ, USA): A 27-gauge regular dental needle was positioned into the coronal part of the canal. While the irrigation solution was being transferred from the needle, the irrigation solution was activated sonically. A K-file number 15 was used with SonicMax for activating the irrigation solution. The file was introduced into the canal and advanced up to 1 mm shorter than the WL. The file was placed into the center of the canal without contacting to the root canal wall.

Group 3 (RinsEndo) (Dürr Dental GmbH & Co KG, Bietigheim-Bissingen, Germany): The irrigation solution was delivered by the activation of RinsEndo hand piece by using its own needle (size 45 with a lateral opening of 7 mm). The delivery rate at 6.2 min. mL/min based on the manufacturer's instruction. The RinsEndo was positioned in the coronal third of the canal without binding and kept constant during the irrigation procedure.

Group 4 (MNI): *Manual Syringe and Endo-EzeNeedle (Endo-Eze,* Ultradent, South Jordan, UT, USA): The needle was placed into the canal 2 mm shorter than the WL without any binding. During the transfer of the irrigation solution, the needle was moved 1-2 mm in the corona-apically to protect the needle against tightness in the root canal and activate the solution.

Group 5 (PUI): Size 15 file and an ultrasonic device (Suprasson Pmax Satelec, Acteon, Marignac, France) was used with the PUI group (Irrisafe K 15 Satalec, Marignac, France). The file was placed 1 mm shorter than the WL. The root canals were irrigated during PUI with a copious irrigation and the solution was activated ultrasonically with the vibrated file at power setting 5. The file was positioned into the center of the canal and there was no contact between the needle and canal wall.

Group 6 (**EndoVac)** (Discus Dental, Culver City, CA, USA): Master delivery tip (MDT) was placed into the coronal part, and during the transfer of irrigation solution to the coronal part, the macro-cannula was advanced into the canal. Aspiration of the solution via the macro-cannula was done with 1-2 mm corona-apical motion. Afterwards, in the same manner, as MDT transferred the solution to the coronal part, the micro-cannula was applied into the canal 1 mm shorter than the WL, by using 1-2 mm corona-apical motion.

During the final irrigation, the extruded irrigation solution was collected into the vial. For each material the test apparatus was weighed using a sensitive scale three times and the mean measurement was recorded as final weightiness. The alteration between the first and the latest weight was recorded. The difference provided us the weight of the extruded amount of the irrigation solution.

Statistical analysis

Statistical Package for the Social Sciences for Windows, version 21 (SPSS Inc., Chicago, IL, USA) was used. Data were shown as a median (min-max). Determining the differences in median apical extrusion between the different techniques was evaluated by Kruskal-Wallis test and if the p value from the Kruskal-Wallis test was statistically significant, Conover's multiple comparison test was applied to determine for the variations between the groups. Less than 0.05 p value was considered as a statistical significance.

Results

Table 1 represents the amounts of apically extruded irrigation solution as mean ± standard deviation. CCMax and EndoVac groups showed no apical extrusion, and these two groups were statistically significantly different from the others (MNI, SonicMax, PUI, and RinsEndo systems); ($p < 0.05$). There was no statistically significant difference between SonicMax, MNI, and PUI ($p > 0.05$). Maximum apical extrusion was observed with RinsEndo

(3.7g). The difference between RinsEndo and SonicMax and MNI was statistically significant ($p < 0.05$), but not PUI ($p > 0.05$). The extent of extrusion from least to most was as follows (Table 1).

	Extruded amount of irrigant (g)				
	GROUPS	N	mean	minimum	maximum
Final-Initial (weight)	*CCMax*	10	0.0±0.00 *a b c d*	0.0	0.0
	SonicMax	10	1.5±0.48 *a e f*	1.0	2.4
	RinsEndo	10	3.7±1.38 *b e g h*	1.5	5.6
	MNI	10	1.3±0.59 *c g i*	0.7	2.5
	PUI	10	1.7±0.34 *d k*	1.2	2.5
	EndoVac	10	0.0±0.00 *f h i k*	0.0	0.0

CCMax<EndoVac<MNI< SonicMax <PUI <RinsEndo ($p < 0.05$).

Table 1. The extent of extrusion.

Discussion

The efficiency of any irrigation material is related with its chemical effectiveness as well as its volume, the contact time, insertion of the irrigation needle, type and the needle diameter, and the transporting systems of the irrigants.[8] In the present study the objective was to assess the amount of extruded irrigation solution using CCMax, SonicMax, RinsEndo, MNI, PUI, and EndoVac systems for the final irrigation due to recently increasing popularity of transporting systems.

Penetration depth influences the amount of the extrusion. As the needle is advanced, the risk of the extruding amount increases and also the amount of the debris into the periapical tissues, and may cause pain, swelling, and tissue damage.[16]

Mitchell et al.[17] has shown that, in the MNI group, the syringe delivery of irrigation solution allowed fully control of the technique because of the depth of needle penetration in the canal and volume flushed through the apical region. Our results were similar to their study as MNI ranked second after the negative irrigation systems (EndoVac and CCMax), with only 1.3g amount of extruded solution.

In our study, both CCMax and EndoVac, representing the negative pressure systems, prevented extrusion of the irrigation solutions from the apex. No one of the negative irrigation systems showed extrusion of the solution beyond the apex in any of the patterns. The results of this study was in accordance with previous studies widely, which noted that irrigation with the EndoVac system resulted in safe irrigation to the WL.[9,17,18] With the EndoVac system, the negative pressure was removing the pulled amount of irrigation into the canal and removed by negative pressure at the WL. However, to our knowledge, there is presently no study about CCMax in the literature in terms of the amount of the extruded material. Based on our experience, although the CCMax irrigation system showed no apical extrusion, the dispersion of aerosol is one of the disadvantages of its clinical usage.

The result of this study correlated with a previous study, which noted that irrigation with RinsEndo resulted with a higher risk of apical extrusion.[10]

In this study, the continuous irrigation was used with the PUI and SonicMax irrigation systems. There was no statistically significance between MNI, SonicMax and PUI.

The volumes of extruded irrigation solution in our research were greater than expected. Because our target was to observe only the effect of the irrigation techniques on extrusion of the irrigation, the barrier effect of the periapical tissues were not into consideration. In some of the studies the potential effect of periapical tissues by evaluating the amount of extrusion into vials were fully neglected.[19,20] Desai and Himel[16] designed their study to maximize the possibility of extrusion through an unobstructed, and normal apex. The model which was used almost certainly show a relationship by design, to a canal that is open to atmospheric pressure.

It is clear that when the barrier technique was used, the extrusion volume decreased. Salzgeber and Brilliant[21] showed in an *in vivo* study in 1977 that the periapical tissues procured a block to the extrusion of irrigation solution in vital healthy teeth. The apical penetration ensued in its random distribution throughout the apical lesion in necrotic cases. It is important to know that results may also differ in the existence of normal or pathological periapical tissues. Therefore, in that manner an *in vivo* study possibly will represent different results.

On the other hand, in this study, gravity was ignored. Gravity may be effective on the extrusion of solutions from the apex. In the literature, all the extrusion studies were made with the apex of the teeth placed in the vial-down

side position, representing a mandibular tooth. However, gravity may have effect the amount of the extruded volume from the apex as it may sway the ease of access of the solution to the apex. Recently it was shown that independent to the irrigation technique used, the amount of irrigation solution extruded from the apex presented a significant difference which linked with the gravity. More extruded amount was observed in mandibular position.[22]

In this study, crowns were removed so that irrigation solutions were not retained in the coronal reservoir. This may have affected the loss of solution to coronal side, and may have decreased the hydrostatic pressure towards the apex. A further study could be designed without decoronation of the sample teeth.

Conclusions

The negative pressure irrigation systems (CCMax and EndoVac) were demonstrated to be significantly more successful and safer in terms of apical extrusion in this study.

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Declaration of Interest

There is no conflict of interest in this study.

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