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Effect of Apical Diameter on the Apical Extrusion of Sodium Hypochlorite: An *In Vitro* Study

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Abstract

Introduction: Sodium hypochlorite (NaOCl) irrigation is crucial to the success of endodontic treatment due to its tissue dissolving capacity and antimicrobial action..However the extrusion of irrigants on activation remains a cause for concern during activation. There is a greater possibility of extrusion in the case of open apices. The Aim Of This Study Was To Evaluate The Amount Of Apical Extrusion Of Sodium Hypochlorite In Open Apices Versus Fully Formed Apices With Different Modes Of Activation. Methodology: Fifty-Four Teeth Were Divided Into Two Groups Comprising 26 Teeth Each According To The Apical Diameter Size. The Teeth In Each Group Were Further Divided Into Three Sub-Groups According To The Method Of Activation (Manual Dynamic, Sonic Or Ultrasonic) .Following Activation, The Amount Of Extruded Irrigant Was Collected And Measured. Statistical Analysis Was Performed With Independent Sample T-Test And One Way Analysis Of Variance. Results: Statistically Significant Difference Was Seen Between The Amount Of Extrusion Seen In The Simulated Open Apices And Fully Formed Apices . The Amount Of Extrusion Seen With Ultrasonic Group Was Found To Be Significantly Lower As Compared To The Other Groups. Conclusion: Activation Of Irrigants May Be Carried Out At The Middle Third To Reduce The Incidence Of Extrusion. Ultrasonics Were Proven To Be A Safer Mode Of Activation In Open Apices In Terms Of Extrusion.

Keywords: Irrigant Activation, Irrigant Extrusion, Open Apex, Sodium Hypohlorite,

Introduction

Chemomechanical debridement is an important part of endodontic treatment. Elimination of pulpal tissue, microbiota and their by-products, and organic and inorganic debris removal by using instruments and intracanal irrigants are objectives of this important phase of treatment[1,2] .

Sodium hypochlorite is able to achieve the goal of chemical debridement. Several investigations have shown its antibacterial effectiveness and tissue dissolution capacity. Sodium hypochlorite carries risk of extrusion into periapical tissues causing inflammation, ecchymoses,

hematoma, and sometimes even necrosis and paresthesia.[3,4,5]

Several methods have been developed since the past few decades to improve the efficacy of NaOCl within the canal by means of irrigant agitation such as Manual Dynamic Activation (MDA), sonic activation and ultrasonic activation

The treatment of necrotic immature teeth has always been a clinical challenge for several reasons. Primarily, it is difficult to achieve an appropriate apical seal with an open apex by performing a conventional root canal treatment. In addition, the suspended development of dentin after pulpal necrosis can result in thin dentinal walls that make the tooth more prone to fracture.[10] Therefore, the disinfection of the root canal only depends on chemical disinfection. However, inadvertent irrigant extrusion toward the periapical tissues has been reported in a number of case studies.[11,12,13]

There has no study to date that has compared the amount of extrusion of sodium hypochlorite in open apices to fully formed apices at differing levels of the canal.

Thus, the aim of this study was to evaluate the amount of apical extrusion of sodium hypochlorite in open apices versus fully formed apices with different modes of activation. Also evaluated was the amount of irrigant extrusion when the activation was carried out at different levels from the working length. The null hypothesis being that the mode of activation would have no effect on the irrigant extrusion at differing levels

Materials and Methodology

On approval from the ethics committee, a total of 54 freshly extracted human mandibular premolars were collected for this study. The teeth were observed under a dental operatory microscope (Moller Wedel, Wedel, Germany) under a 25X magnification to check for caries, fractures, resorbtive defects, calcifications, open apices, previous endodontic treatment .These were then excluded from the study. The samples were cleaned of any residual tissue tags using an ultrasonic scaler(Acteon,Michigan,North America), rinsed under running water and stored in 10% formalin(Balaji Formalin, Maharashtra, India) until use.

A pilot study was first carried out using 6 samples. On obtaining the results, it was then followed up by the complete study.

The samples were decoronated at the level of the CEJ using a diamond disk (Kerr, Orange, USA). The working length of the tooth was standardised at 17mm and was verified using a #15 K-file(MANI Inc, Toshigi-Ken, Japan) using a direct visual inspection of the file through the apex . The working length was then adjusted to 0.5 mm short of the anatomic apex. Access to the pulp chamber was made using an Endo Access kit (Dentsply,Michigan,USA).

The samples were then randomly divided into 2 main groups of 24 samples each:-

Group I: Standard Chemomechanical Preparation: The samples were instrumented till F3(#30.09) using Protaper rotary files(Dentsply, Michigan, USA) and EDTA gel(Prime Dental, Maharashtra, India). Irrigation was carried out using 5.25% sodium hypochlorite(Septodont, Pennsylvania, USA) and recapitulation was done after every successive file.

Group II: Modified Organotypic Protocol(Simulated Open Apices): The teeth were then instrumented using K-files(MANI Inc, Toshigi-Ken, Japan) and EDTA gel(Prime Dental, Maharashtra, India) up to size #130 to create an apical opening of 1.3 mm in diameter and simulate an open/immature apex. K-files were preferred as they would induce a lesser degree of micro-crack formation. The apex was then refined using a #4 Peeso Reamer(MANI Inc, Toshigi-Ken, Japan) under normal

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saline(Fresensius Kabi, Bad Homburg vor der Höhe, Germany) Trevino et al.[14] suggested the organotypic model for creating immature apex wherein an instrument of a size 130 was used. Since a #130 K-file corresponds to size 130, it was used to simulate an immature apex.

Each group was then sub grouped as follows:-

Group A:Manual Dynamic Activation: 2.5 ml of 5.25% sodium hypochlorite (Septodont, Pennsylvania, USA) was first administered. The irrigant was then activated using a #30.06 gutta percha point(Diadent, Antennestraat 70, 1322 AS Almere, Netherlands) which was cut 3mm from its tip. Activation was carried out at levels 14mm,11mm and 8mm from the apex using gentle upward and downward strokes for 1 minute.[6]

Group B:Sonic Activation: 2.5 ml of 5.25% sodium hypochlorite was first administered using a side vented syringe. Sonic activation was carried out using an Endoactivator (Dentsply, Michigan, USA) at levels 14mm, 11mm and 8mm from the apex. This was carried out for 1 minute[7].

Group C:Ultrasonic Activation: 2.5 ml of 5.25% sodium hypochlorite was first administered using a side vented syringe. Ultrasonic activation was carried out using U-files(Endostar, Warsaw, Poland) at levels 14mm, 11mm and 8mm from the apex. This was carried out for 1 minute.[8]

Collection Apparatus

Experimental model to collect the extruded irrigants Experimental model used in this study was based on the Myers and Montegomery model [15]. A vial with a rubber stopper was taken and a hole was created with a heated instrument in the centre of the rubber stopper. The tooth was then inserted under pressure into the rubber stopper which was fixed to the cemento-enamel junction using cynaoacrylate glue. Another glass vial (smaller in size than the previous vial) that fits tightly into the suspended apical portion of the root was used as the collecting container. The whole assembly of rubber stopper with the collecting container was inserted into the main vial. To equalize the pressure, a 23gauge needle was inserted into the rubber stopper. The irrigation protocol was performed in each group and the irrigant extruded periapically was collected. The volume of extruded irrigant was measured by using a calibrated collection vial

Statistical Analysis

The mean values were summed up, tabulated and were then subjected to analysis using the independent sample T-test . Intra group comparison was carried out with One way Analysis of Variance.

Results

Results showed a statistically significant difference between the amount of extrusion seen in the simulated open apices and fully formed apices.

The amount of extrusion seen with ultrasonic activation group(7.05µl, 9.08 µl, 11.3 µl) was found to be significantly lower (P value:<0.05) as compared to the other sub-groups in the open apices group(Table 1).

Regarding the volume of irrigant extrusion at the different levels. A significantly lower level of extrusion(12.1

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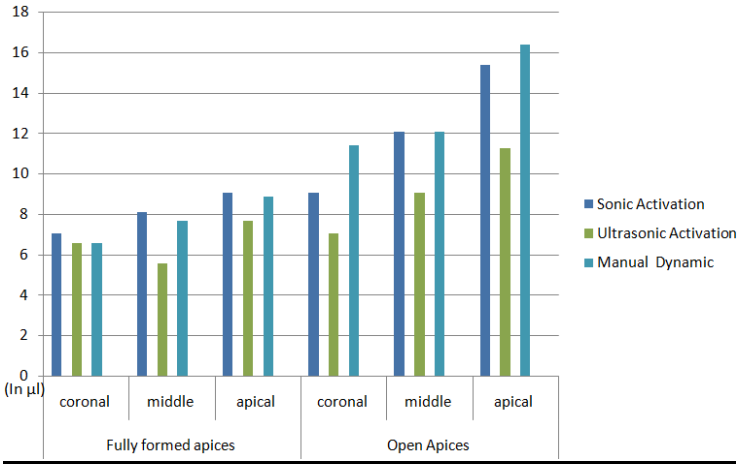
µl,9.08 µl and 12.1 µl with sonic, ultrasonic and manual dynamic groups respectively) was seen at the middle third as compared to the coronal and apical thirds in the open apices group(P value:<0.05) (Table 1)

Table 1

		Type Of Activation						
		Sonic Activation		Ultrasonic Activation		Manual Dynamic		
		Mean (in µl)	SD	Mean (in µl)	SD	Mean (in µl)	SD	P values (inter group)
Fully formed apices	coronal	7.06	1.8	6.56	1.4	6.6	3.09	0.004
	middle	8.09	2.9	5.55	2.5	7.7	2.06	0.003
	apical	9.08	2.4	7.66	2.4	8.9	1.36	0.002
Open Apices	coronal	9.09	1.04	7.05	1.3	11.4	1.33	0.004
	middle	12.1	1.11	9.08	2.5	12.1	2.05	0.032
	apical	15.4	1.06	11.3	1.4	16.4	1.31	0.001
P values (intra group)		0.010		0.005		0.012		

Table 2



Discussion

Although a number of different solutions have been proposed for root canal irrigation, sodium hypochlorite in various concentrations (0.5–5.25%) is the most frequently used irrigant (Grossman 1981).[16] This is mainly due to its tissue-dissolving capacity as well as to its antibacterial properties. Commercially available irrigation devices have been developed with the aim of improving the delivery of irrigant throughout the root canal by using ultrasonic or sonic energy.

Irrigation of the root canal system includes a risk of extrusion of the irrigant into the periapical region; in the case of irrigation with sodium hypochlorite (NaOCl), this can be associated with pain, swelling, and tissue damage .[17,18,19,20]Apical extrusion of water was significantly reduced when using sonic or apical negative pressure devices compared with syringe and side-port needle or passive ultrasonic irrigation (PUI) with continuous irrigant flow .

As reported by Trevino et al[14], NaOCl when used for disinfecting the immature root canals should be used with caution. Immature teeth have a large apical opening and thin divergent or parallel dentinal walls and hence with conventional needle irrigation there is a very high possibility of extrusion.

However, previous studies have not compared the amount of extrusion seen with fully formed apices as compared to open apices.

The results of this in vitro study demonstrate that both method of activation and level of activation of NaOCl into the apical one-third play a role in the amount of extrusion into the apical tissues.

Trevino et al [14]. suggested the organotypic model for creating an immature apex wherein an instrument to the size of 130 was used [10]. In this study, we followed a modified organotypic model protocol with K files (upto size #130), which was used to prepare a constant 1.3 mm diameter without destroying the structural integrity of the root.

A statistically significant difference between the amount of extrusion seen in the simulated open apices and fully formed apices. This is in correlation with a study conducted by Ross Paton et al [22] who reported similar findings in his study.

An experimental apparatus was utilised for the collection of the extruded irrrigant based on the setup by Myers and

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Montgomery. Each tooth was secured for instrumentation and debris collection by the root being forced through a precut hole in a #1 rubber stopper. A 15- • 45-ram glass shell vial (Kimble, Toledo, OH) was used as the collecting container for any debris or irrigant extruded during instrumentation. This vial was placed into a glass flask (20-ml scintillation vial; Kimble) with the rubber stopper fitted securely into the mouth of the flask. The apex of the root was suspended below the upper rim of the collection vial (Fig. 1). The use of the collection vial was a modification of the technique used by Fairbourn et al.[23] for debris collection. A 25-gauge needle was placed alongside the stopper during insertion to equalize the air pressure inside and outside the flask.

An apical diameter of size 0.30mm was chosen for the fully formed apices group. This was based on a study conducted by AC Tinaz et al[27] in 2005 wherein they concluded that a size 0.30mm diameter allowed for optimum disinfection with minimum extrusion.

The amount of extrusion seen with ultrasonic activation group(7.05µl,9.08 µl,11.3 µl) was found to be significantly lower ()P value:<0.05) as compared to the other sub-groups in the open apices group(Table 1).Thus,the null hypothesis was rejected. This may attributed to to the effect of acoustic streaming inside the canal, which can move the solution inside the canal from the apical toward the coronal direction[9]. Moreover, the decoronated teeth do not provide a coronal reservoir for the irrigation solution. When activating the intracanal solution using ultrasonic a considerable amount of solution may be lost coronally, decreasing the hydrostatic pressure towards the apex.

Sonic activation produces higher amplitude and tip movement as compared to ultrasonic activation. This would explain the greater amount of extrusion with regards to the Endoactivator group.[7]

A significantly lower level of extrusion(12.1 µl,9.08 µl and 12.1 µl with sonic,ultrasonic and manual dynamic groups respectively) was seen at the middle third as compared to the coronal and apical thirds in the open apices group(P value:<0.05) (Table 1).This is in accordance with a study conducted by Zoi Psimma[24] et al. They reported that the the extrusion of irrigants decreased as the needles were moved away from the working length.

The experimental model was designed to imitate conditions in vivo by simulating open apices. However, caution should be exercised before extrapolating these results to the clinical situation,as the factor of vapor lock [26] has not been taken into account which is observed in the clinical scenario.

Future studies could evaluate negative pressure modes of activation on open apices using the same collection protocol.This would include methods such as the Endovac system[25] .Studies have shown a significantly lesser amount of extrusion as compared seen with the Endovac system to sonic and ultrasonic modes of activation, in both in-vitro and in-vivo studies .

Conclusion

Within the limitations of this study, we can conclude that the recommended level of activation in immature apices should be placed at the middle thirds with regards to sonics and ultrasonics. Also, ultrasonics were proven to be a safer mode of activation in both mature and open apices as compared to sonic modes of activations.

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