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Efficacy Of Different Irrigation Activation Systems On The Penetration Of Sodium Hypochlorite. An In-vitro Simulated Canal Study

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Abstract
The removal of vital and necrotic pulp tissue & microorganisms is essential for the endodontic success. However, the complex anatomy of the root canal system has limited the ability of complete debridement especially of the lateral, accessory and secondary canals. The aim of this study was to evaluate the effect of currently used irrigation and activation systems on the penetration of sodium hypochlorite into simulated lateral canals and to working length in a closed system.
Method: One hundred single rooted teeth were used in this study. A total of 600 lateral canals were created, 6 in each tooth, with 2 lateral canals at 2, 4.5, and 6 mm of working length. To resemble the clinical situation, a closed system was created by coating each root with soft modeling wax. Roots were then randomly divided into 5 experimental groups using different irrigation activation systems: Group 1 (n = 20) Endoactivator (sonic activation); Group 2 (n = 20) Passive ultrasonic (PUI) activation; Group 3 (n = 20) Plastic Endo File (F file); Group 4 (n = 20) 6% GP Activation; and Control group5 (n = 20) Conventional End venting needle irrigation. The samples were evaluated by direct observation of the images recorded under the dental operating microscope. Statistical analysis was performed.
Results: In the passive ultrasonic irrigation (PUI) the irrigant effectively reached the working length and penetrated lateral canals.
Conclusion: PUI demonstrated that the irrigant reached the working length and penetrated into the lateral canals effectively when compared to the other groups.

Key Words
Irrigation, Endoactivator, PUI, F-File, 6% GP, End Venting Needle, WaveOne

Introduction

The complex anatomy of root canal systems has limited our ability to predict endodontic success. The removal of vital and necrotic pulp tissue, microorganisms and their toxins, along with the effective smear layer removal is a prerequisite for successful endodontics.[1],[2]Shaping of the root canal space can be done using hand or rotary files. The main objective of this shaping is to remove infected dentin and facilitate the delivery of the irrigant till the apical third while preserving the patency of the canal and integrity of the tooth.[3],[4]

An irrigation protocol plays a key role in disinfecting and debriding root canal system aiding in desired fluid tight obturation. Two factors directly correlate with efficient irrigation, the irrigant and the delivery system. An ideal root canal irrigant must have broad antimicrobial spectrum, high efficacy against anaerobic and facultative microorganisms, inhibit dissolution of necrotic pulp tissue, inactivation of endotoxin and removal of the smear layer after instrumentation.[5]Some of the popular irrigants include Sodium hypochlorite (NaOCl), Chlorhexidine (CHX), Ethylenediaminetetraacetic acid (EDTA), MTAD. However, NaOCl remains the gold standard as a result of its antimicrobial effect and tissue dissolution properties.[6]

Root canal irrigation systems can be divided into 2 categories, manual agitation techniques and machine-assisted agitation devices.[7] Manually positive pressure during irrigation is commonly performed either by using a small gauge needle or agitation with gutta percha, k-files and h-files. Machine-assisted irrigation techniques include sonic and ultrasonic and newer systems like apical negative pressure (ANP) irrigation and the plastic rotary file.[8],[9] Two important factors to be considered during the process of irrigation are the delivery of the irrigant to the whole extent of the root canal system, particularly at the apical third and whether it is capable of debriding areas impossible with mechanical instrumentation, such as lateral canals and isthmi.

The roots are surrounded by periodontium and the root canal system behaves like a close-ended channel, which results in gas entrapment at the apical third producing a vapor lock effect, thus preventing the flow of irrigant into the apical region and adequate debridement.[10] So it is critically important to investigate which irrigation system effectively irrigates the whole canal as well as isthmi and lateral canals. Therefore the aim of this study was to evaluate the effect of different activation systems on the penetration of NaOCl into simulated lateral canals and up to working length in a closed system.

Materials And Methods

This comparative study involved 100 single rooted teeth consisting 20 teeth in each group. Any visible calculus was removed ultrasonically and single root

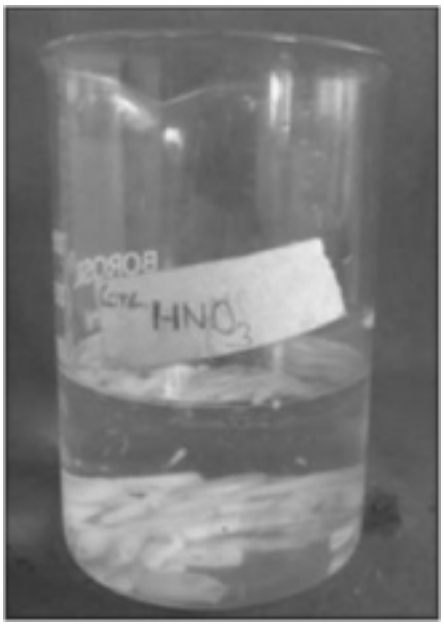

Fig. 1 Decalcification by immersing teeth in 5% Nitric Acid for 36 hours

Fig. 2 Preparation of lateral canals.

canals were confirmed using RVG. Standardized access cavities were made for specimen using Endo access bur kit. Working length was determined using RVG. Shaping of the canals was done using waveOne primary files till working length. The files were lubricated using EDTA (RC-HELP) during shaping procedure and 5% NaOCl as irrigant.

After the completion of shaping of the root canal space the teeth were rendered

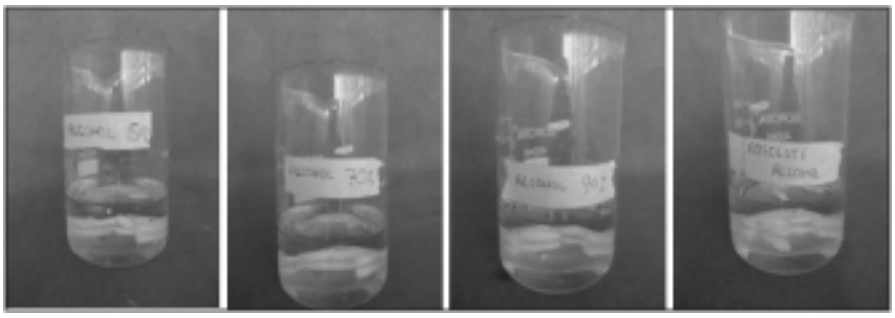

Fig. 3 Dehydration of the teeth using increasing percentages of alcohol concentrations (50, 70, 90 & Absolute)

Fig. 4 Immersion in Methyl Salicylate Dye for clearing the teeth

clear by using the modified technique described by Robertson and Leeb[11] following the protocol of Georgio et al.[12] In brief, the teeth were decalcified by immersing them in 5% Nitric Acid (HNO3) for 36hours. **(Fig. 1)** The lateral canals were then prepared using #10 K-Files at 2, 4.5 & 6mm from the apex. **(Fig. 2)** The teeth were then kept under running water for 5hours. The teeth were then dehydrated using increasing series of alcohol concentrations (50%, 70%, 90% & Absolute). **(Fig. 3)** The teeth were then immersed Methyl Salicylate Dye and cleared. **(Fig. 4)**

Contrast irrigating solution methylene blue was then delivered and activated by different systems and the penetration of the solution was observed under dental operating microscope. **(Fig. 5)** As Endoactivator was not available with the institution where the study was undertaken it was procured from Government Dental College & Hospital, Mumbai after acquiring permissions

Fig. 5 Different Irrigation activation devices used. (GROUPS)

from the principles of both the colleges.

Groups

Group 1 (n = 20) EndoactivatorSonic activation was delivered by using the Endoactivator with a red 25/.04 tip, inserted at working length and activated for 30 seconds.

Group 2 (n = 20) Passive ultrasonic (PUI) Ultrasonic activation was performed with a stainless steel ultrasonic file ISO 20 mounted ultrasonic unit. The file was passively inserted at working length and activated for 30 seconds by using a power setting of 3.

Group 3 (n = 20) Plastic Endo File (F file) The F-File was used with an electric slow speed hand piece set at 600 rpm. An ISO 20.04 plastic file was passively introduced to working length and activated for 30 seconds.

Group 4 (n = 20) 6% Gutta Percha ActivationThe 6% G.P. was used with up and down motion 2mm from the apex for 30 seconds.

Control Group 5 (n = 20) Conventional End Venting Needle Irrigation Teeth of this group were irrigated with positive pressure Irrigation by using a 25-gauge end vented needle and syringe at 2 mm short of working length during a period of

Table 1. Results showing significant difference by PUI when compared to the other groups.

	GROUP 1 Endoactivator (20)	GROUP 2 PUI (20)	GROUP 3 F-File (20)	GROUP 4 GP (20)	GROUP 5 Positive Pressure (20)	P Value
Reached wl	10	15	8	5	0	<0.1
Any canals penetrated						
Overall	5	20	2	1	0	<0.1
2mm	0	14	0	0	0	<0.1
4.5mm	2	20	0	1	0	<0.1
6mm	3	20	2	0	0	<0.1
No. of canals penetrated (mean) Standard deviation	0.8	3.8	0.2	0.3	0.0	<0.1

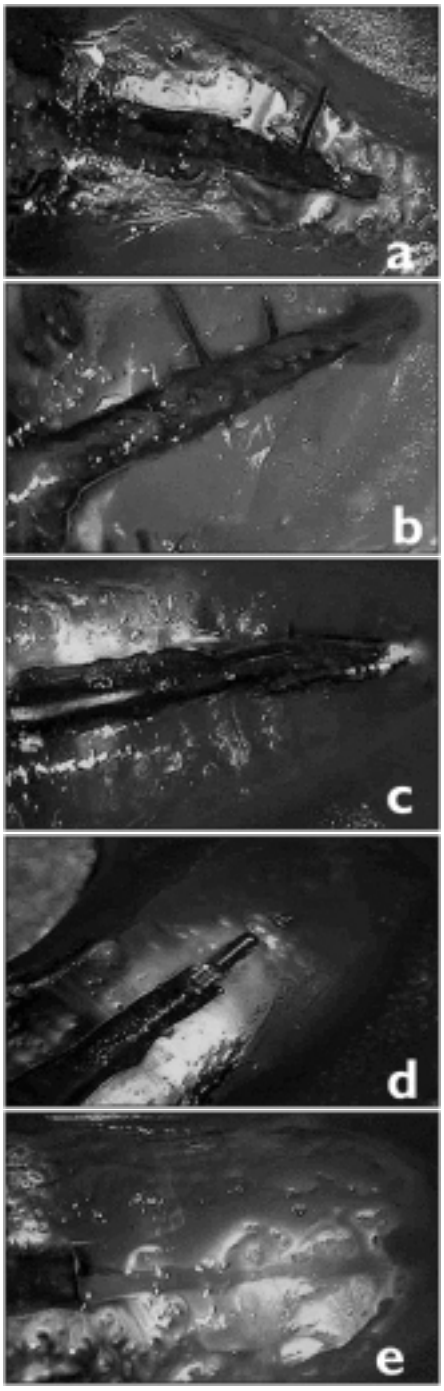

Fig. 6 Microscopic results of each GROUPa. Endoactivator, b. PUI, c. F-File, d. GP, e.End venting needle

30 seconds.

Evaluation Criteria and Statistical Analysis

The samples were assessed by direct observation under the dental operating microscope under 25x magnification. Irrigant penetration was measured by the number of lateral canals in which the contrast solution penetrated at least 50% of the total length. The outcome was assessed in each tooth at each of the 3 working lengths (2, 4.5, and 6 mm).

The X2 test was used to analyze irrigant penetration to working length and lateral canals, and The Kruskal-Wallis test was used to evaluate the number of canals penetrated.

Results

All the groups had 20 samples and were observed under the microscope. An illustrative microscopic image of each group can be seen in **(Fig. 6a-e)**. As seen in **Table 1** group 2 (PUI) showed statistically significant difference when compared with the other groups for both the irrigant reaching the working length and penetrating into the lateral canals.

Discussion

The most vital aspect of root canal treatment is the effective removal of bacteria from the root canal system. The efficacy of intracanal irrigation has been evaluated and reported in the endodontic literature. [13],[14],[15] An irrigant must be in direct contact with the tissue to be disinfected.[16] The irrigant should always be delivered to full length of the root canal system and activated in the apical area specially because of thevariations in the root anatomy like lateral canals, apical deltas, accessory canals becoming the source of treatment failure.[17] Therefore, this study evaluated the effect of currently used irrigation and activation systems on the penetration of commonly recommended NaOCl into complex root anatomy by simulating lateral canals and up to working length.

The results obtained are in agreement with studies that have shown that sonic or ultrasonic activation might allow a better removal of pulpal tissue remnants and debris from complex anatomy of the root by effective penetration of the irrigants.[18],[19] It has also been reported that an irrigant in conjunction with ultrasonic vibration, which generates a continuous movement of the irrigant, is directly associated with the effectiveness of the cleaning of the root canal space.[20],[21]

The results of present study are in accordance with a study by Cesar de Gregorio et alwhere Endovac and ultrasonics were compared for the activation of the irrigant and concluded: Endovac was effective for the irrigant to reach the working length but ultrasonics was more effective in penetration into the lateral canals as well as reaching working length.[22] Boutsioukis et al [23] had concluded that when using positive pressure irrigation, the needle should be placed to within 1mm from working length to ensure fluid exchange. This recommendation, although physically correct, is biologically unsafe as a result of the possibility of extrusion of NaOCl into periradicular tissues.[24] The intracanal pressure produced by small-diameter needles can reach up to 400–550 kPa which can also contribute to a possible NaOCl accident.[25]

The presence of an apical vapor lock created by the organic decomposition of NaOCl into a bubble of carbon dioxide and ammonium should also be considered. Our results are also in coherence with a study by Tay F et al, where it was stated that presence of an apical vapor lock adversely affects debridement efficacy when using positive pressure irrigation and also found ultrasonics to be most effective.[26]

Conclusion

Within the limitations of the results of present study, Passive Ultrasonic Irrigation efficiently irrigated the root canal system in all the samples tested. PUI successfully reached the working length as well as penetrated the lateral canals. PUI was followed by Endoactivator, F-File, Gutta

Percha & End venting needle.

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