Original Article

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Dentistry Section

Comparison of Penetration of Irrigant Activated by Traditional Methods with A Novel Technique

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ABSTRACT

Introduction: The effectiveness of irrigation depends upon various irrigation activation methods & devices used.

Aim: To compare and evaluate the penetration of irrigant upto working length and into simulated lateral canals using four different irrigation activation techniques.

Materials and Methods: The root canals of 60 single-rooted teeth were instrumented using the proTaper rotary system. After decalcification of each sample tooth, three simulated lateral canals were created at 2mm, 4mm and 6mm levels from the root apex using a 06-size C+ file. After clearing the samples they were randomly assigned into four experimental groups (n=15) and 1ml of Irrigating Contrast Solution (ICS) was delivered into all samples and then it is activated with 4 different methods Group I-Conventional syringe and needle, Group II - Sonic activation with Endo activator, Group III – Ultrasonic activation with ultrasonic tips and Group IV - Activation using reciprocation movement. All the samples were examined under a stereomicroscope and irrigant penetration was evaluated by means of penetration of ICS.

Results: Group III and Group IV resulted in better penetration of ICS into lateral canals at 2mm and 4mm depth ($p<0.001$), when compared with Group I and II. At lateral canals 6mm all the groups except Group I, had shown 100 % penetration.

Conclusion: The activation of irrigant using reciprocation was able to achieve penetration of irrigating contrast solution both up to the working length and into lateral canals. Hence the clinical significance of this method of irrigant activation is that it can be used for effective penetration of irrigants both upto working length and into lateral canals.

Keywords: Irrigating contrast solution, Reciprocation, Simulated lateral canals, Sonicactivation, Ultrasonic activation

INTRODUCTION

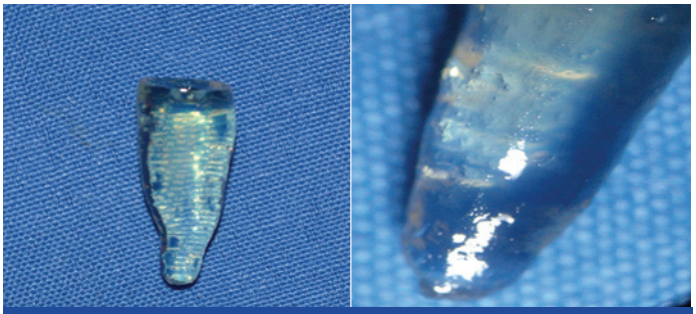
Thorough disinfection of the root canal system is considered a key requirement for successful root canal treatment. Traditionally it is accomplished by a combination of instrumentation and irrigation [1]. Thus the outcome of endodontic treatment depends upon mechanical instrumentation and effectiveness of irrigating solutions [2]. Microorganisms remain in the root canal despite of cleaning and shaping procedures. This is because of complexities in root canal morphology consisting of isthmuses, lateral canals, fins, and deltas which harbour bacteria, debris and necrotic tissue [2]. Regardless of the instrumentation technique, 35% or more of the root canal surfaces remains uninstrumented [3]. Hence the ability of the irrigant to penetrate into areas not instrumented by mechanical instrumentation is critical for debridement and disinfection of the root canal system. There is a clear correlation between lateral canals obturation and healing of periapical lesions [4]. However, in order to fill lateral canals, these should be thoroughly cleaned [5]. Therefore mechanical instrumentation along with chemical disinfection will result in better canal cleanliness [6].

Currently, a variety of irrigation techniques and devices like ultrasonic, endovac are being used to improve the disinfection of root canal system. However, the conventional endodontic irrigation syringe and needle is the most widely used delivery system. Chow showed that the efficacy of apical irrigation is directly related to the depth of insertion of the needle, which in some cases presents a challenge to the clinician [7]. Ultrasonic and Sonic devices effectively deliver irrigants to the apical third [8-10]. Sonic activation produces mechanical oscillation, mainly at the tip of the file, with frequency ranging from 1 to 6 KHz, whereas Ultrasonic activation produces transverse vibrations with high frequencies but low amplitude [11]. However, the safety of these methods has yet to be evaluated. Hence in the present study a novel method of activation of irrigant using reciprocating motion was done. The present study aimed at the comparison of penetration of irrigant activated by traditional methods with the activation by using reciprocating movement.

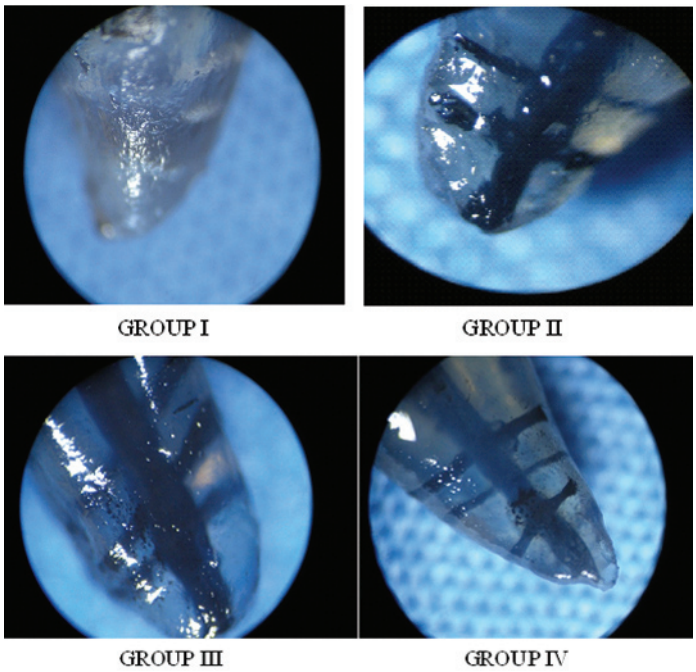
MATERIALS AND METHODS

The present study was conducted in MNR Dental College and Hospital Sanga reddy in the year 2015. Sixty human single-rooted maxillary teeth with straight root canals were selected. Teeth were kept in 4% NaOCl (sodium Hypochlorite) for 2 hours, and any visible calculus removed ultrasonically. The teeth were radiographed in both buccolingual and mesiodistal direction to verify the presence of single canal. They were decoronated at the cemento enamel junction and examined under dental operating microscope to confirm the presence of single canal. The patency of the root canals was obtained using a size 10 K-file (Maillefer, Ballaigues, Switzerland). The root canals were instrumented using the ProTaper rotary system in the sequence of Sx, S1, S2, F1, F2, and F3. After each file 1.5ml of 5.25% NaOCl was delivered using a 27-gauge side port Monojet needle for 30 seconds.

After the instrumentation, teeth were subjected to modified clearing protocol described by Venturi et al., [12]. Teeth were submerged in 5% nitric acid for 36 hours, for decalcification, with the solution being replenished every 8 hours. After completeness of decalcification the teeth were cleaned under tap water for 3 minutes, to remove any traces of acid, if presented. Lateral canals were then created inserting 06C+files at 2mm, 4mm and 6mm from apex the buccal and lingual walls perpendicularly to the external surface. Samples were then dehydrated by subjecting to 60% ethyl alcohol for 12 hours followed by 80% for 1 hour and 96.6% for 1 hour. Finally they were cleared and stored in 99.9% methyl salicylate [Table/Fig-1]. Thus a total of 360 simulated lateral canals were created, with two lateral canals at each depth i.e. at 2, 4 and 6 mm in every sample. Then they were mounted in rubber based impression material to mimic the presence of surrounding



[Table/Fig-1]: Specimens of cleared tooth: a) Direct observation; b) Observation under stereomicroscope at 30X magnification



[Table/Fig-2]: Stereomicroscopic pictures of samples: Group I (Conventional syringe activation); Group II (Sonic activation); Group III (Ultrasonic); and Group IV (Reciprocation)

periodontal tissues.

The cleared specimens were divided into 4 groups with 15 teeth per group (n=15). Irrigating Contrast Solution (ICS) was prepared by mixing 40% of Indian ink with 60% of NaOCl (5.25%) in the ratio of 2:3 [13]. This solution enhances the visibility of irrigant penetration. One ml of ICS was delivered into all samples and then activated by four different methods; conventional syringe, sonic, ultrasonic and reciprocation. The depth of penetration of the contrast solution into the lateral canals and up to the working length was used as a means to evaluate the penetration of the irrigants.

Group I: Conventional Syringe irrigation with Manual Agitation: In this group samples were irrigated with positive pressure irrigation using 25 mm, 30 gauge side vented needle, the syringe being placed 2 mm short of the working length, and 1 ml of ICS was delivered for a period of 30 s by moving the syringe up and down in the canal. This method of activation creates the hydrodynamic activation of the irrigant and reduces the chance of apical extrusion [14].

Group II: Sonic activation group: After the ICS was delivered by positive pressure irrigation at 2 mm from the working length, activation was done using Endoactivator [α] set at 10,000 cycles per minute with a 25/.04 tip inserted 2 mm short of working length for 30 sec.

Group III: Ultrasonic activation group: Ultrasonic activation was performed using a stainless steel, noncutting, and ultrasonic Irri Safe size 20 file mounted on a Suprasson Newtron XS ultrasonic unit [β]. After the delivery of ICS into the canal the file was inserted passively 2 mm short of the working length and was activated for a period of 30 seconds using a power setting of five.

Group IV: Irrigant activation with Reciprocating motion: In this method after ICS was delivered into the canal, 25/.02 RACE file was used with ES-100 endomotor in reciprocation motion (back and forth movement) till the working length for 30 seconds. This novel reciprocating motion uses a large counter clockwise rotation and a smaller clockwise rotation that resembles a safe reverse "balance force" manual motion. During reciprocation movement file gradually follows the canal and simultaneously carries the irrigant into continuously tapering funnel shaped canal.

[α] DentsplyMaillefer

[β] Satelec Aceton Group

EVALUATION CRITERIA

All the specimens were observed under stereomicroscope at 30X magnification with eye piece lense 10X and objective lense 3X and feild size of 6.57 mm for evaluation of irrigant penetration [Table/Fig-2]. Samples were scored on the basis of penetration of ICS up to the working length and into simulated lateral canals [6] [Table/Fig-3].

Scoring criteria	Working length	Lateral canals
Present	If penetration till working length	If penetration >50%
Absent	No penetration	If penetration < 50%

[Table/Fig-3]: Scoring criteria for evaluation of Irrigant Penatration

Scoring was performed at all the three levels independently. A total of 360 lateral canals per group (90 lateral canals at each level that is at 2mm, 4mm and 6 mm from the apex) were assessed. All samples were scored by two trained evaluators who were blinded for group assignment pertaining to each sample.

STATISTICAL ANALYSIS

All the analysis was done using SPSS version 18. A p-value of <0.05 was considered statistically significant. Comparison of irrigant penetration among the study groups was done using Chi-square test [Table/Fig 4].

RESULTS

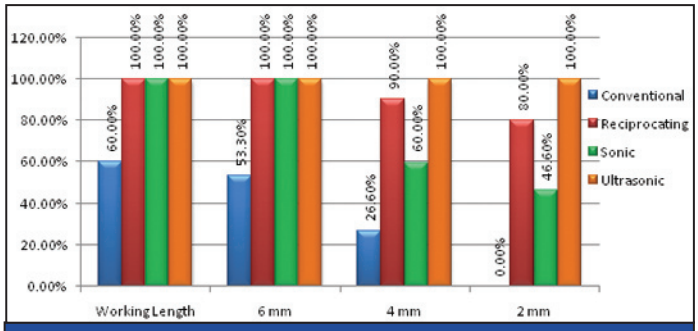
ICS penetration upto working length and into lateral canals at 2mm, 4mm and 6mm depth when activated by different methods

		Group								p-value
		I		II		III		IV		
		N	%	N	%	N	%	N	%	
Working Length	Absent	6	40.0%	0	.0%	0	.0%	0	.0%	0.004; Sig
	Present	9	60.0%	15	100.0%	15	100.0%	15	100.0%	
6mm	Absent	14	46.6%	0	.0%	0	.0%	0	.0%	<0.001; Sig
	Present	16	53.3%	30	100.0%	30	100.0%	30	100.0%	
4mm	Absent	22	73.3%	12	40.0%	0	.0%	3	10.0%	<0.001; Sig
	Present	8	26.6%	18	60.0%	30	100.0%	27	90.0%	
2mm	Absent	30	100.0%	16	53.3%	0	.0%	6	20.0%	<0.001; Sig
	Present	0	.0%	14	46.6%	30	100.0%	24	80.0%	

[Table/Fig-4]: Satistical evaluation of groups for irrigant penetration. p-value of < 0.05 was considered as statistically significant

(Group I conventional, Group II sonic, Group III ultrasonic and Group IV reciprocation) were evaluated. A p-value of < 0.05 was considered as statistically significant.

There was significant penetration of ICS till the working length in all the groups except in the Group I (Conventional) which showed penetration only in the 60% of the samples. In lateral canals at 6mm the Groups II, III and IV have shown penetration of ICS in all the samples whereas in Group I (Conventional) penetration of ICS was seen only in 53.3 % of sample size. In lateral canals at 4mm Group III ultrasonic activation had shown penetration of ICS in 100 % of canals followed by Group IV reciprocation in 90% of canals, Group II sonic activation in 60% of canals and Group I only in 26.6% of the canals. In lateral canals at 2mm Group III ultrasonic activation had shown penetration of ICS in 100 % of canals followed by Group IV reciprocation (80%), Group II sonic (46.6%) and Group I (0%) [Table/Fig 5].



[Table/Fig-5]: Graph showing the penetration of ICS up to working length and into lateral canal at 2mm,4mm and 6mm depth, when activated by different methods

DISCUSSION

Effectiveness of irrigation is ensured only when irrigant comes in contact with entire root canal system. Several delivery systems and new agitation devices developed for better distribution of irrigant throughout canal system which results in improved canal cleanliness. Hence it is beneficial to agitate the irrigant after passive irrigation, regardless of level of needle insertion, volume of solution used or apical taper of the preparation [11].

The classic laboratory techniques for the evaluation of root anatomy and irrigant distribution include clearing of teeth and injection of an opaque material (India ink or dyes). Currently, this is the accepted method by which three-dimensional irrigant penetration can be assessed in an extracted tooth [15-18]. Viscosity and surface tension play a role in the penetration of the irrigants within the root canals. The viscosity and surface tension of ICS is almost similar to that of NaOCl [19]. Hence in the present study, irrigant penetration was assessed by clearing the tooth and observing the extent of penetration of ICS up to working length and into lateral canals. However, in the previous study for assessment irrigant penetration by de Gregorio et al., a sample size of 20 cleared teeth (n=20) per group were evaluated and study by Spoorthy et al., sample size of 16 teeth (n=16) per group were evaluated. But in the present study sample size of 15 teeth (n=15) per group were evaluated. This is because the sample size was selected based on the results of pilot study which have shown a highly statistical significant difference between the groups.

When using side vented syringe, irrigant penetration was limited only 1 to1.5 mm apical to the needle tip for all flow rates tested [20]. Hence, when using side vented syringe, the needle should be placed within 1mm from working length to ensure fluid exchange. This recommendation, although physically correct, is biologically unsafe because intracanal pressure produced by small-diameter needles can reach up to 400–550 KPa which can contribute to the possibility of extrusion of irrigant into periradicular tissues [20,21]. In group - I (*conventional*), irrigant activation was done using 29 gauge side vented needle by moving up and down in the canal. This method will cause hydrodynamic activation of irrigant and allows the irrigant to reflux, prevents the extrusion of the irrigant into periapical tissue and displaces the debris coronally [22]. The results in the study showed that there was no penetration of ICS into lateral canals particularly at the apical third. This might be related to the presence of gases in the apical region forming a vapour lock into which further fluid penetration is difficult [23].

In group II the *sonic activation* of the irrigant has been used. The results show that sonic activation is superior to needle irrigation but inferior to ultrasonic activation. These results are also in accordance with reports of other studies by Castelo-Baz et al., Spoorthy et al., de Gregorio [13,19,24].

Passive Ultrasonic Irrigation was first described by Weller et al., However the term 'passive' is a misnomer as it was named after 'noncutting' action of the ultrasonically activated file, but as it is in fact active. PUI transmits acoustic energy from an oscillating file to irrigant in the root canal. In group III Ultrasonic activation was done. In this technique, the ultrasonic tip is placed in the centre of canal without any intention to instrument, plane or contact the canal walls with the file. Results showed that ICS penetrated into all the lateral canals. The efficacy of PUI for irrigant penetration into the lateral canals may be due to the file oscillation that has the potential to create *a*coustic streaming and cavitation effects, which allows the irrigant to flow into the irregularities accessing untouched areas [10]. The effectiveness of the PUI system achieved in this study is in accordance with the studies by Bronnec et al., 2010, de Gregorio, Jensen et al., [1,24,25].

In group IV, a novel method of irrigant activation by *reciprocation* movement was used. Results obtained in the study showed its efficacy is inferior to ultrasonic activation but superior to sonic activation. This method had shown the penetration of ICS into lateral canals present even in the apical third. This was because of the churning effect of reciprocating movement which carried the ICS to the working length and into lateral canals. The RACE (Reamer with Alternating Cutting Edges), system which was used in reciprocation has a combination of a triangular section with alternating cutting edges ensures more space for the irrigant, which allows the adequate swirling of irrigant and efficient penetration. As the non cutting tip was used, it ensured sure guidance/centering of the file in the canal and can be safely used at the apex even for 30 sec. As 2% taper file was used it was loosely fitting and did not cause any apical transportation. The results of this study show that activating irrigant with file remaining essentially loose inside the main body of the canal, after shaping systematically brought solution to the apical end of the canal. It is hypothesized that the tapered preparation probably gave reflux space allowing the irrigating solution to flow up and down along the file, with the solution being displaced outward when the file is inserted at length and flowing inward when it is removed. In previous studies irrigant penetration using different activation devices such as ultrasonics and endoactivator were compared. But till date no study has evaluated the irrigant penetration using reciprocation motion for irrigant activation.

Though the ultrasonic activation had shown the best results during the activation unintentional contact of the ultrasonic tip to canal wall may occur due to the dimensions and complex geometry of the root canal system [26]. Apart from damping of the file motion and reduction of the cleaning efficacy [27,28], such contact could also lead to uncontrolled removal of dentin [29]. However, to date, the file-to-wall contact during ultrasonic activation or its effect on file oscillation has not been fully evaluated. Since the efficacy of irrigant agitation is inversely proportional to the extent of wall contact of an irrigant delivery or agitation device it is difficult to standardize the positioning of the ultrasonically activated instrument in the centre of the root canal and to standardize the displacement amplitude as a small constraint in the canal. This will

have a direct effect on the efficacy of PUI. Considerable file-to-wall contact will occur during irrigant activation. Therefore, the term 'Passive Ultrasonic Irrigation' should be amended to 'Ultrasonically Activated Irrigation' [30].

CLINICAL SIGNIFICANCE & LIMITATIONS OF STUDY

This novel method of irrigant activation using reciprocation movement can be used for effective penetration of irrigants both upto working length and into lateral canals. However the apical extrusion of the irrigant has to be evaluated with this method of irrigant activation. Further studies are required for invivo use of irrigant activation using reciprocation.

CONCLUSION

The activation of the irrigant using reciprocation had shown results comparable to the ultrasonic activation. So this method can be used effectively with no need of specialised equipment for the irrigant activation.

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