Effect Of Maintaining Apical Patency And Two Different Irrigation Modalities on Irrigant Penetration into the Apical Two Millimeters of Large Root Canals: An In Vivo Study

Dr. Maulsree Guleria[1], Dr. Saumil Dwivedi[1] ,Dr. Rahul Shrivastava[2], Dr. Deepak Singh Kirar[1], Dr Vartul Dwivedi[3], Dr Monisha Tiwari Mishra[1]

[1]Assistant Professor, Mansarovar Dental College, Bhopal
[2]Associate Professor, Mansarovar Dental College , Bhopal
[3]Professor, People's Dental Academy, Bhopal

Abstract

AIM: To determine the effect of maintaining apical patency and two different agitation protocols on irrigation penetration into the apical 2 mm of large root canals.

MATERIALS AND METHODS: Total of 76 large human root canals from teeth with either irreversible pulpitis or necrotic pulps were assigned into two groups. Apical patency was maintained in one group (P) during shaping and cleaning procedures with a no. 10 K-file 1 mm beyond the working length but not in the other group (no-patency). All canals were treated following the same preparation protocol to size 40/0.06 by using 2.5% NaOCl as irrigant during preparation procedure. Before obturation, canals were irrigated with 1 mL of a radiopaque solution by using passive and agitation-irrigation technique, and radiograph was obtained. Digital images were taken, and 2 calibrated readers determined the presence or absence of the irrigating solution in the apical 2 mm of the root canals.

RESULTS: Active-irrigation significantly improved irrigant penetration in apical 2mm when compared to Passive-irrigation in Group no patency (p=0.021). In Group-patency, improved irrigant penetration was seen in both active-irrigation (92.10%) and passive-irrigation modality (86.84%) with no statistically significant difference (p=0.899) between two irrigation modalities. Statistically significant difference (p=0.035) was found in the percentage of canals with irrigant in the apical 2 mm when comparing the Patency (86.84%) with the Non-Patency group (60.52%) when passive- irrigation modality was used.

CONCLUSION: Maintaining apical-patency with a no. 10 K-file and manual-dynamic-agitation improves the delivery of irrigants into the apical third of large root canals.

KEYWORDS: Root canal irrigation; manual dynamic agitation; apical patency; contrast media

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Introduction

Effective irrigant delivery and agitation are prerequisites for successful endodontic treatment.[1]Many investigators using advanced techniques such as microcomputed tomography (CT) scanning have demonstrated that proportionally large areas of the main root-canal wall remain untouched by the instruments, emphasizing the importance of chemical means of cleaning and disinfecting all areas of the root canal especially apical third of root canal. The complete debridement in the apical third, has proven to be a difficult task because of the anatomic complexity. Till date there is no single irrigating solution that sufficiently covers all of the functions required from an irrigant.[2]

However, among currently used solutions, sodium hypochlorite (NaOCl) appears to satisfy most of

the requirements for a root canal irrigant.[3]It has the unique capacity to dissolve necrotic tissue and the organic components of the smear layer.[4]

The mode of application of NaOCl solution is a factor that has gained little attention in endodontic studies. Moorer and Wesselink opined that mechanical agitation or fluid flow was more important in the ability of NaOCl to dissolve tissue than the initial percentage of available active chlorine.[5]

Manual dynamic activation (MDA) has been described as a cost-effective technique for cleaning the walls of the entire root canal. Manual dynamic activation (MDA) involves repeated insertion of a well-fitting gutta-percha cone to the working length (WL) of a previously shaped canal. The gutta-percha cones then applied in short strokes will activate the irrigant. Gu et al. hypothesized that this technique might be useful in breaking the air bubbles located at the apical 0-2 mm of the canal with repeated gutta-percha insertion.[1]

It is known that the establishment of apical patency with a small file through the foramen is able to prevent the accumulation of debris in the apical portion of the root Canal.[6]In previous studies, maintaining apical patency throughout the cleaning and shaping procedure in small canals improved irrigant delivery into the apical third compared with those canals in which apical patency was not maintained.[7]Furthermore, maintaining apical patency led to a significant reduction of gas bubbles in the middle third of root canals.[8]

However, to date no published study has investigated the true extent of intracanal irrigation flow after root canal preparation in large canals and its relationship with effect of maintaining apical patency as well as agitation protocols.

Hence, the aim of present study is to determine effect of maintaining apical patency on irrigation penetration into the apical 2 mm of large human root canals. Also, to determine irrigant penetration into the apical 2 mm of large human root canals using two different irrigation modalities.

Materials and Methods

This research was conducted with the approval of the institutional review board.Informed consent from patients participating in the study was obtained. Patients visiting the Outpatient Department of Conservative Dentistry and Endodontics in Bapuji Dental College and Hospital, Davangere, Karnataka were selected for the study. Exclusion criteria were an allergy to any of the components of the formula, pregnancy, or failure to sign informed consent.

Total of 76 large human root canals from teeth with either irreversible pulpitis or necrotic pulps consisting of the palatal roots of maxillary molars, distal roots of mandibular molars with one canal and anterior teeth, measuring between 19 and 21 mm were randomly assigned by a coin toss into separate groups: the no patency (NP) group (n=38) and the patency (P) group (n=38).

Irrigation protocol

All teeth were anesthetized with 2% lignocaine with 1:100,000 epinephrine. After teeth were isolated with rubber dam**,** conventional access cavities were prepared with the help of a high-speed hand-piece.The coronal flaring of the cervical third of the root canals was performed, no.15 K-file was used to determine the working length (WL) with the ProPex II Apex locator (Dentsply) which was confirmed radiographically.The canals were prepared using ProTaper instruments (Dentsply Maillefer) in a 16:1 controlled-torque, low-speed rotary handpiece at 300 rpm, to apical size 40 with a 0.06 taper.

The NP Group

Passive irrigation with a flow rate of 1 mL per 15 seconds of the irrigating solution (2.5% sodium hypochlorite) was used with the help of Luer lock 26-guage open ended needle which was placed 3 mm short of the working length.

A no. 10 K-file was taken to the WL (no patency) using a push-pull motion between each instrument followed by passive irrigation with 1mL of the 2.5% NaOCl, with the needle placed 3mm short of WL with an in-and-out gentle movement of the syringe.

The P Group

The same procedure was performed for group P, but the 10 K-file was inserted 1mm past the WL to maintain patency between each instrument and before each irrigation sequence.

Irrigation modalities

The study groups were further divided on the basis of irrigation modalities.

Subgroup PI

After completion of canal shaping, 1 mL of 2.5% NaOCl was delivered into the canal. Finally, canals were irrigated with 1mL of Iohexol (Omnipaque) contrast medium with the same needle also placed at 3mm short of working length. A radiographic imageof the extent of irrigant flow was obtained for each tooth with parallel technique at the same angle and exposition.

Subgroup AI

After completion of canal shaping, 1 mL of 2.5% NaOCl was delivered into the canal. Finally, canals were irrigated with 1mL of Iohexol (Omnipaque) contrast medium with the same needle also placed at 3mm short of working length. Activation of irrigant was done with well-fitted gutta-percha point which was inserted in the canal and moved in-and-out to working length (3 short vertical strokes with a 5 mm amplitude) and removed before taking a radiograph for the active irrigation modality.

Evaluation

Two teeth in vivo were used as positive controls in which the radiopaque solution was placed into the canal to determine whether it could be detected by an examiner. Four teeth were used as negative controls in patients receiving root canal therapy wherein no intracanal radiopaque solution was used. Two blinded, calibrated readers determined the presence or absence of the irrigating solution in the apical 2 mm of the root canals which was recorded in the form of no (absence of irrigating solution) or yes (presence of irrigating solution).

Statistical analysis:

Descriptive statistics were generated in terms of percentages.Chi Square test was used to find significant difference between the proportions.

Results

Radiopaque irrigant was present in the canals of both positive controls and absent in the negative controls.

Discussion

Sodium Hypochlorite is an effective disinfectant when it comes into direct contact with bacteria biofilms, it produce clean and debris-free dentin surfaces only in the coronal and middle thirds but not in the apical third of the canal wall when used in conjunction with nickel-titanium instruments.[9]Consequently, different irrigant agitation techniques have been proposed to increase the efficacy of the irrigant solutions. Some of these techniques include manual agitation with hand files, manual agitation with gutta-percha cones, mechanical agitation with plastic instruments, and sonic and ultrasonic agitation.[1, 10, 11]Therefore, thepresent in vivo study was designed to quantify irrigant penetration and renewal in apical third of canal.

Numerous in-vitro studies have aimed to determine irrigant penetration in apical third of the canal using different irrigation modalities. The main limitation of those studies is that it relies on the assumption of an impermeable apical foramen whereas irrigation solution pressure could exceed the positive back-pressure of periapical tissues in vivo.[12]So, an in vivo experimental approach was considered suitable for this study.

Radiographic contrast media are widely used in medicine; however, their use in dentistry has been limited.In thepresent study, Iohexol (Omnipaque) was used as contrast medium,because it is a non-ionic, monomeric, and water-soluble iodide solutionalso with similar density and viscosity as 5.25% NaOCl. In contrast toHypaque, Iohexol has the advantage of being a low-osmolality agent(Hypaque osmolality has been reported to be more than twice higher)that it is readily available in a sterile, pyrogen-free, nontoxic solution.[13, 14]

In the present study, conventional endodontic 26 gauge open-ended needle was used as it allows comparatively easy control of the depth of needle penetration within the canal and the volume of irrigant that is flushed through the canal. According to Boutsioukis et al. (2010), irrigant replacement is more effective with an open-ended needle than a closed-ended one.[15] In the recent survey conducted by Gopikrishna et al among the endodontic teaching faculty and post-graduate students in the dental colleges present in India, 97% of respondents indicated that 26 gauge needle was being employed as the primary irrigation needle for the delivery of endodontic irrigants.[16]In the present study 26 gauge open ended needle along with large sample size was used in order to have an applicability concern with general clinical scenario. The results might at least be qualitatively transferable to a clinical situation.

The needles evaluated in the present study were positioned at 3 mm short of the WL. This distance was chosen based on preliminary simulations, as

to create a challenging case for both groups and allow evaluation of the flow apically to the needle tip. Therefore, it does not comprise a clinical suggestion.[17]

All large canals used in this study were prepared to a standardized 40/0.06 caliber with the Protaper rotary system. This apical diameter allowed the penetration of the 26 gauge needle 3mm short of working length, because it has a 0.46-mm diameter.

Sodium hypochlorite was used during the whole preparation procedure to allow the hydrolysis of organic tissue present in the pulp chamber and root canal systems. It has been demonstrated that this chemical reaction leads to the formation of small bubbles of ammonia and carbon dioxide, and because the root canal behaves as a closed tube system, these bubbles get trapped in the closed end of the tube. This situation has been previously described as the vapour lock effect in the endodontic literature.[1, 8]

The result of the present study indicated that significant difference was found in the percentage of canals with irrigant in the apical 2 mm when comparing the Patency with the Non-Patency group when passive irrigation modality was used.($P=0.035$). Also, there were significantly($P<0.05$) more canals with irrigant in the apical 2 mm after shaping with a 40/06 instrument when manual dynamic agitation was performed.

The results of this in vivo study confirm that a 26-G open-ended needle in combination with a low-flow rate is not very effective in applying irrigant solution in the apical root canal beyond the needle tip. It has been shown in previous study done by Boutsioukis et al that irrigant refreshment can be expected 1 mm beyond the needle tip when an open-ended needle is used in combination with a relatively high-flow rate. As expected from an in vitro study, a lower-flow rate, as used in this study, will probably negatively influence irrigant penetration.[17]

Although the absence of the radiopaque solution could very well be caused by a lack of penetration of the irrigant or the presence of pulp tissue in the apical root canal, another reason could be the presence of an apical air bubble caused by the irrigation procedure or by the reaction of irrigant with organic tissue.[18]The presence of gas bubbles not only apically but in the middle and cervical thirds of human root canals was recently shown in an in vivo study conducted by Vera et al (2012).[8]

In the present study, maintaining apical patency with a no. 10 K file 1mm beyond working length resulted in more canals having irrigant in apical third after agitating the irigant with manual dynamic agitation. It may be that a patency file facilitates removal of the air bubble or vapour lock effect[18]although the influence of the patency file and manual dynamic agitation on the penetration of irrigating solution had not been studied *in vivo* before.

The results of this study showed that activating irrigant with a well fitted gutta-percha point after shaping systematically brought solution to the apical end of the canal.This can be attributed to better solution refreshment in apical third of the canal. Manual dynamic agitation allow the irrigating solution to flow up and down the along the cone, with the solution being displaced outward when cone is inserted at length and flowing inward when it is removed.[19]

The effect of manual dynamic agitation on irrigant penetration have been studied before by various investigators,[9,12, 20, 21]but till this date no in vivo study has been conducted to evaluate true extent of irrigant flow. The result of the present study are in accordance with an in vitro study done by Bronnec et al where authors showed that penetration of the irrigating solution was significantly improved when manual agitation of the irrigant was performed.[12] Also, McGill et aland Huang et al demonstrated that manual-dynamic irrigation was significantly more effective than an automated-dynamic irrigation system (RinsEndo) and static irrigation.[20,22]As for the patency technique, the findings of present study is in accordance with the study done by Vera et al.[7, 18]

Although newer needle designs and irrigation devices have been introduced in the field of dentistry, still most of practitioners are making the use of 26 gauge open ended needle.[12] As suggested by present study, 26 gauge needle along with passive irrigation is not suitable method for delivery of an irrigant in the apical third. Therefore, in these clinical situations manual dynamic agitation and patency technique could be used as effective adjuncts. These two techniques are simple and cost effective that enables solution to flow and completely flood the root canal system.

In conclusion and within the limitations of this study, maintaining apical patency and manual dynamic agitation improved the delivery of irrigant into the apical third of large human root canals with an apical size of 40 and 6% taper. Further in vivo studies are suggested to investigate the effectiveness of patency technique and manual dynamic agitation in terms of root canal cleanliness and disinfection result.

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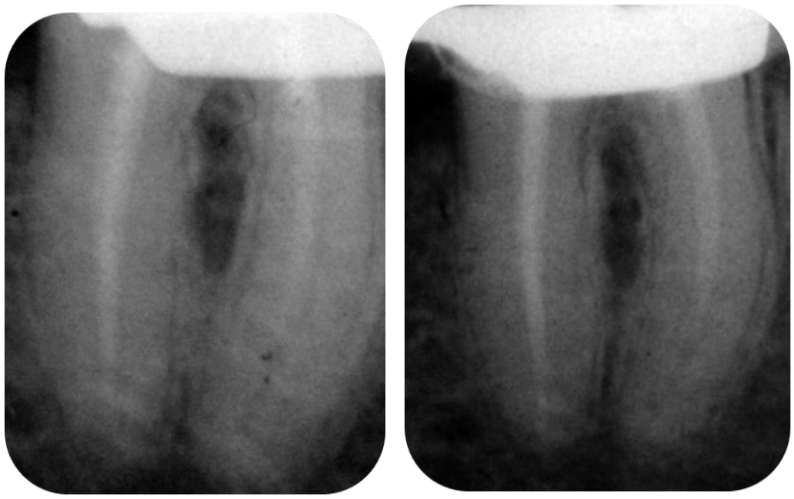
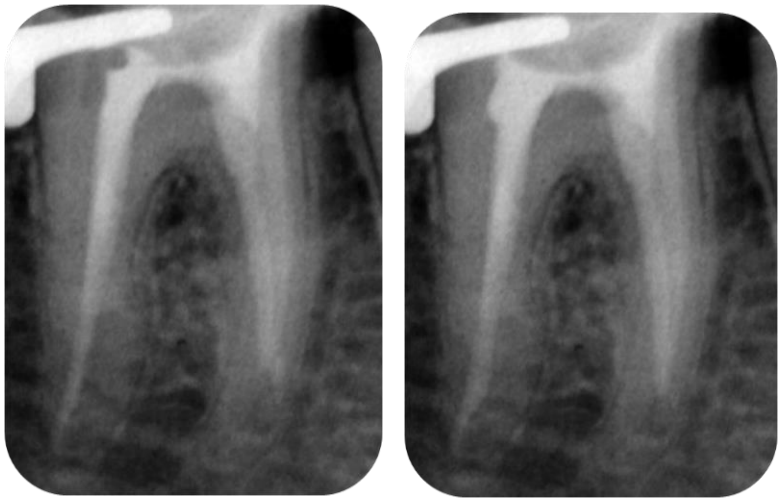
Figure 1: Representative samples from Group No-Patency



Passive irrigation **Active irrigation**

Figure 2: Representative samples from Group Patency



Passive irrigation **Active irrigation**

Figure 3: The presence of irrigant in the apical 2mm, n (%)

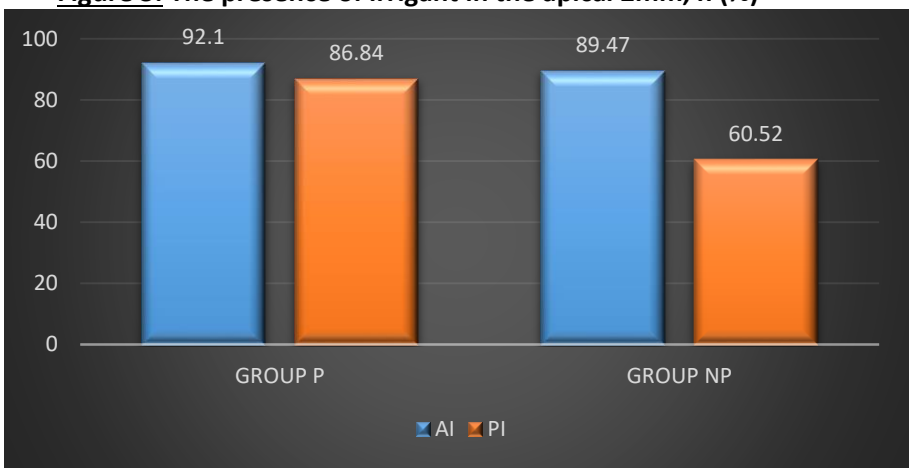


Table 1: The presence of irrigant in the apical 2mm, n (%)

Groups	Active irrigation	Passive irrigation
Group NP	89.47	60.52
Group P	92.10	86.84

Table 2: Comparison of irrigation modalities in group NP by chi square test

	Active irrigation	Passive irrigation	Chi value	P value
Group NP	89.47	60.52	5.25	0.021*

*p<0.05

Table 3: Comparison of irrigation modalities in group P by chi square test

Group	Active irrigation	Passive irrigation	Chi value	P value
Group P	**92.10**	**86.84**	**0.107**	**0.743**

*p<0.05

Table 4: Comparison of group NP and P with respect to active irrigation modality

Irrigation modality	Group NP	Group P	Chi value	P value
Active irrigation	89.47	92.10	0.016	0.8999

*p<0.05

Irrigation modality	Group NP	Group P	Chi value	P value
Passive irrigation	60.52	86.84	4.404	0.035*

Table 5: Comparison of group NP and P with respect to passive irrigation modality

*p<0.05