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EVALUATION OF CLEANING OF ISTHMUSES USING DIFFERENT IRRIGATION TECHNIQUES – AN IN VITRO STUDY

Ashwini Ghogare[1], Shail Jaggi [1], Nitin Shah [1], Jyoti Mandlik[1*] and Nikhil Sharma[2]

1Department of Conservative Dentistry and Endodontics, Dental College and Hospital, Bharati Vidyapeeth Deemed University, Pune, Maharashtra, INDIA
2Department of Conservative Dentistry and Endodontics, Modern Dental College, Indore, Madhya Pradesh, INDIA

ABSTRACT

Purpose: *The aim of this in vitro study was to evaluate the efficacy of different irrigation systems in cleaning the isthmuses and lateral canals in the apical and middle thirds of the root canal.* ***Methodology:*** *Thirty extracted human mandibular first molar teeth were selected for the study. The distal roots of teeth were removed and mesial roots were used for the study. Radiographs of the teeth were taken in bucco-lingual and mesio-distal directions to check the presence of any lateral canals. The samples were randomly divided into three experimental groups (n=10); Group1: Manual agitation irrigation technique, i.e. 30 gauges Navi-tip. Group2: Passive ultrasonic irrigation (PUI) with Ultrasonic tip i.e. Irrisafe. Group3: EndoVac. Canals were prepared using HyFlex files and obturated with gutta flow-2 sealer and gutta purcha point. All the samples were cleared by using the method of tooth clearing adopted from Robertson et al.* ***Method of data analysis****: Morphological analysis was performed using a stereomicroscope to reveal details of accessory canal filling.* ***Results:*** *The samples treated with EndoVac irrigation technique showed maximum number of cleaned lateral canals and isthmuses in the apical as well as in the middle third of the root canals. The PUI technique was better than manual agitation irrigation technique.*

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KEY WORDS

Isthmuses; Manual Irrigation techniques; Passive Ultrasonic Irrigation; EndoVac Irrigation Technique; Chemo-mechanical Preparatio,; HyFlex files; Tooth Clearing Technique; Gutta flow-2 Sealer and gutta percha

***Corresponding author:** **Email:** drjyoti8@gmail.com; **Tel:** +91- 9421385056

INTRODUCTION

The success of endodontic treatment depends on the eradication of microbes from the root-canal system and prevention of reinfection. The root canal is shaped with hand and rotary instruments under constant irrigation to remove the inflamed and necrotic tissue, microbes/biofilms, and other debris from the root-canal space. The main goal of root canal instrumentation is to facilitate effective irrigation, disinfection, and filling. Several studies 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 [1]. Irregularities in canal systems such as narrow isthmuses and apical deltas prevent complete debridement by mechanical instrumentation alone. An isthmus is often poorly accessible to root canal instruments, irrigants, and medications and acts as tissue and bacterial reservoir, that might account for the failure of nonsurgical root canal treatment [2]. Hence chemo-mechanical preparation is recommended wherein the irrigant serves as a physical flush to remove debris as well as serving as a bactericidal agent, tissue-solvent and lubricant [3].The irrigation technique has influence in cleaning the complex root canal anatomy including the isthmuses. Various irrigation systems have been advocated by the researchers. The purpose of this in vitro study was to evaluate the cleaning of the isthmuses using different irrigation techniques.

MATERIALS AND METHODS

Data collection

The study protocol was approved by the institutional research committee. Thirty extracted human mandibular first molar teeth were selected for the study. The teeth were extracted for either periodontal reasons or poor restorability. The criteria to exclude teeth from

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the study were; teeth with external resorptive defect seen with the naked eye, Hypercementosis, evident root fracture checked by transillumination, incompletely formed apex, extreme root curvature and previous root canal treatment

Preparation of samples

After extraction, the teeth were washed under tap water. The distal roots of teeth were removed and mesial roots were used for the study. All the samples were stored in normal saline for further use. Radiographs of the teeth were taken in bucco-lingual and mesio-distal directions to check the presence of any lateral canals. The samples were randomly divided into three experimental groups (n=10).

- Group1- Manual agitation irrigation technique, i.e. 30 gauge Navi-tip.
- Group2- Passive ultrasonic irrigation with Ultrasonic tip i.e. Irrisafe.
- Group3- EndoVac.

Endo-access cavity was done for all samples. Working lengths were established by introducing a size 06 K-files until the tip could be seen at the foramen. Root Canal instrumentation was performed with hand K-files 8, 10, 15, 20 till full working length and then rotary Hyflex file (0.60) system was used. During instrumentation, the chamber was flooded with 5% NaOCl replenished after each instrument.

Preparation for group 1

Manual agitation irrigation technique was performed with 30 gauge Navi-Tip. For irrigation 3 ml of 5% NaOCl was used. The irrigant was delivered after use of each instrument using a 30-gauge side vented needle for 15sec, then canal was rinsed with normal saline and after completion of instrumentation, the canal was agitated with 17% EDTA for 15 Sec.

Preparation for group 2

Passive ultrasonic activation was performed with a Irrisafe ultrasonic tip ISO 10 (Satelec Acteon Group, Merignac Cedex, France) mounted on a Suprasson P5 Booster ultrasonic unit (Satelec Acteon Group). The file was inserted 2 mm short of the working length and passively activated using a power setting of 3, according to manufacturer's recommendations. The file was passively inserted into the canal without any filing motion. This procedure was performed in three cycles of 20 seconds each for a total activation time of 1 minute.

Preparation for group 3

Root canal procedure was same as for group 1and 2. Irrigation was done by Endo Vac and 30 gauge Navitip was used as microcannula. For this irrigation protocol, first the macro-irrigation was accomplished over a 30 second period this was done by using the macro-cannula which was constantly moved up and down in the canal from a point where it started to bind to a point just below the orifice the canal space was then left undisturbed, full of irrigant for 30 seconds. Three cycles of micro irrigation followed. During a cycle of micro-irrigation the pulp chamber was filled with irrigant while the Navi-tip was placed at the working length for 6 seconds, then it was positioned 2 mm from working length for 6 second and then moved back to working length for 6 seconds. This up and down motion continued until 30 seconds had elapsed. This completed one micro irrigation cycle. The first cycle used 5% NaOCl, as an irrigant, the second cycle normal saline and the third cycle 17% EDTA. The final irrigation was done with normal saline.

The samples from three groups were then obturated with gutta flow-2 sealer and gutta purcha point and cleared using the method of tooth clearing recommended by Robertson et al [4]. Morphological analysis was performed using a stereomicroscope to reveal details of accessory canal filling. Observations were performed by counting the number of visible lateral canals as well as isthmuses within the middle and apical third of the roots. All accessory canals and spaces detected between the canals were observed from all the four surfaces (mesial, buccal, distal and palatal). The complete root was studied under 17X magnification and the areas of interest, the apical 1/3 and the middle 1/3, were studied under 25X magnification.
The scoring was done in the following manner:

0: No filling of lateral canals and isthmuses
1: Partial filling of lateral canals and isthmuses
2: Complete filling of lateral canals and isthmuses

The scores were tabulated and analyzed statistically using Kruskal Wallis ANOVA test for 'within group' comparison.

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RESULTS

"Within group" Comparison, using Kruskal Wallis ANOVA

The analysis of scores obtained by using Kruskal Wallis ANOVA test for the within group comparison at apical and middle third showed that the p-value was more than 0.05.hence the mean values of the number of filled canals were not statistically significant. However, in the EndoVac group, all the samples showed filling either partial or complete, no sample has '0' score and more no of samples (eight) with complete filling **[Table– 1 and 2]** ;The values in the bracket are the percentage and the number indicates the number of samples showing filling).

Table: 1. Comparison of root canal filling in the apical third:

Irrigation techniqe	Type of filling, Number (%)			P value (Kruskal Wallis ANOVA)
	No filling	Partial filling	Complete filling	
Group 1	4 (40)	2 (20)	4 (40)	0.103
Group 2	3 (30)	2 (20)	5 (50)	
Group 3	0 (0)	2 (20)	8 (80)	

Table– 1 shows the filling in the apical third of the samples for all three groups. In Group 1(Navi-tip irrigation group), four samples showed no filling, two samples showed partial filling and four samples showed complete filling in the lateral canals and isthmuses. In Group 2(Passive Ultrasonic irrigation group), three samples showed no filling, two samples showed partial filling and five samples showed complete filling in the lateral canals and isthmuses. In Group 3(EndoVac irrigation group), zero samples showed no filling, two samples showed partial filling and eight samples showed complete filling in the lateral canals and isthmuses.

Table: 2.Comparison of root canal filling in the middle third

Irrigation technique	Type of filling, Number (%)			P value (Kruskal Wallis ANOVA)
	No filling	Partial filling	Complete filling	
Group 1	2 (20)	3 (30)	5 (50)	0.532
Group 2	2 (20)	2 (20)	6 (60)	
Group 3	0 (0)	3 (30)	7 (70)	

Table–2 shows the filling in the middle third of the samples for all three groups. In Group 1(Navi-tip irrigation group), two samples showed no filling, three samples showed partial filling and five samples showed complete filling in the lateral canals and isthmuses. In Group 2(Passive Ultrasonic irrigation group), two samples showed no filling, two samples showed partial filling and six samples showed complete filling in the lateral canals and isthmuses. In Group 3(EndoVac irrigation group), zero samples showed no filling, three samples showed partial filling and seven samples showed complete filling in the lateral canals and isthmuses.

DISCUSSION

For this in-vitro study, thirty freshly extracted human mandibular first molars were used. We selected only mesial root because of their high incidence of canal isthmuses [5]. All the samples of our experiment were obturated with gutta-flow with an assumption that it would flow in all the intricacies of the canals including the isthmuses. But it will flow effectively only if these isthmuses are cleared off debris with the irrigation technique. The main purpose of the present study was to evaluate the potential of different irrigation techniques in clearing the debris from isthmuses and lateral canals and the method we opted for this evaluation was based on this assumption. To observe whether the lateral canals and isthmuses were filled with gutta-flow or not, we used the tooth clearing technique. After clearing, stereomicroscopic examination of the entire length of the sample was done at 17X magnification. The accessory and lateral canals in the apical 1/3 and the middle 1/3, were studied at 25X magnification.

In the present study the group 1 was treated with manual agitation irrigation technique. We used 30 gauge, side vented Navi-tip needle as it could reach the apex, ensuring that the irrigating solution too reaches close to the apex and be mechanically effective. Moser and Heuer from observations of their in vitro study determined that smaller diameter size needle can be placed closer to the apex and can be more efficient in flushing the debris; however the smaller diameter needles require more pressure for activation of the plunger than larger diameter needles [6].

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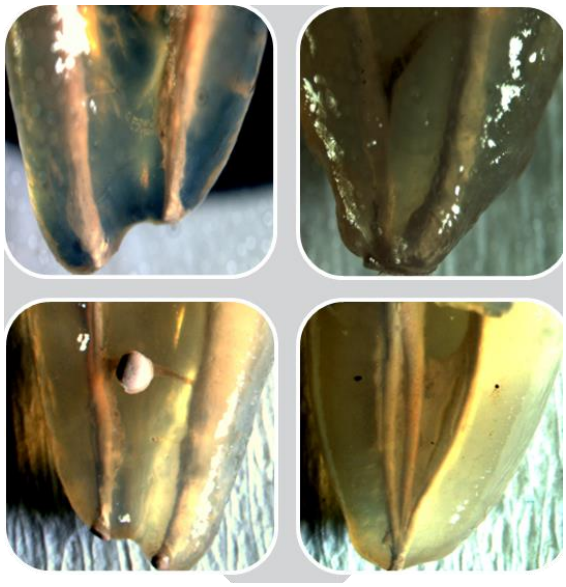

Fig: 1. Stereomicroscopic images of the group 1 (Navi-Tip, manual irrigation) samples

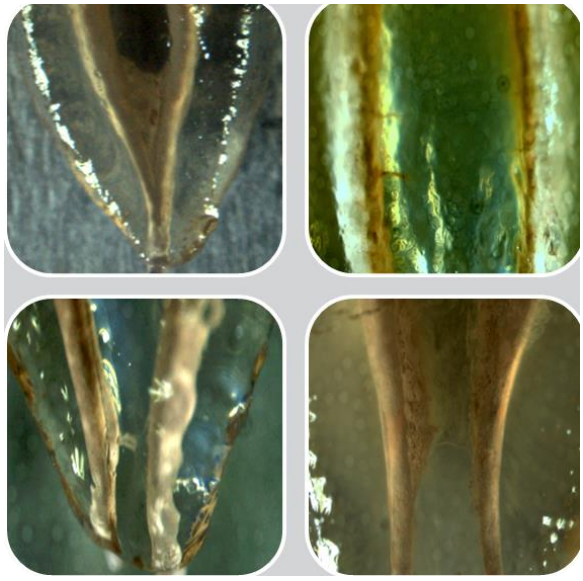

Fig: 2. Stereomicroscopic images of the group 2 (Irrisef, Passive Ultrasonic Irrigation) samples

Ya Shen et al conducted a study to investigate the effect of irrigation needle tip design on irrigant flow pattern by using a 3-dimensional computational fluid dynamics (3D CFD) model. The results showed that needle tip design influences flow pattern, flow velocity, and apical wall pressure, all important parameters for the effectiveness and safety of irrigation. They observed that side vented needle require low apical pressure and hence were safer [7]. In our study the stereomicroscopic examination of the needle irrigation group revealed that in 40% of the samples apical isthmuses were filled with gutta-flow where as isthmuses in middle third were filled with gutta flow in 50% of the samples **[Figure– 1]**. This group was poorest in performance as far as cleaning of isthmuses is concerned.

In the present study the second group recived treatment with Passive ultrasonic irrigation technique. We used Irrisafe instruments. Satelec recommends the IrriSafe instruments for Passive Ultrasonic Irrigation (PUI), the safe

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removal of the smear layer, dentine debris and bacteria from the root canal. The instrument's shape improves micro-streaming and microcavitation in fluids. Non-cutting rounded end prevents damage to the apical constriction [8]. In our study, the stereomicroscopic examination of this group revealed that in 50% of the samples apical isthmuses were filled with gutta-flow where as isthmuses in middle third were filled with gutta flow in 60% of the samples **[Figure– 2]**. The Satelec system used in this study is a piezoelectric unit that does not require an external cooling source and is more powerful than magnetostrictive units. It functions on principal of acoustic streaming and cavitation [9]. The delivery of fresh irrigating solution within the root canal may have contributed to the improved cleanliness values.

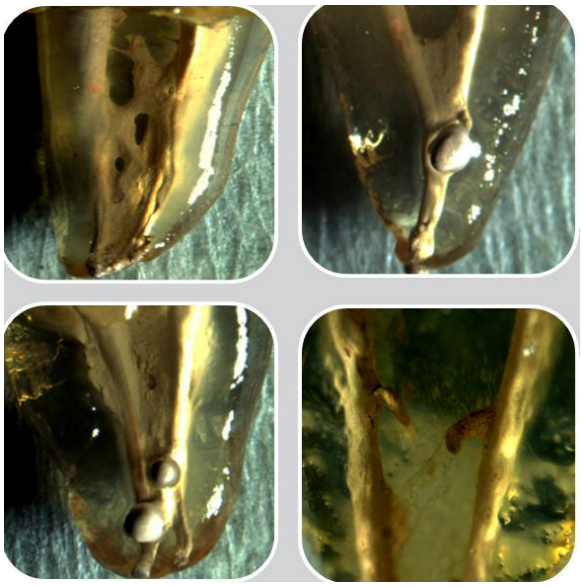

Fig: 3. Stereomicroscopic images of the group 3 (IEndoVac Irrigation) samples

S-J Lee, M-K Wu & P R Wesselink compared the ability of syringe irrigation and ultrasonic irrigation to remove artificially placed dentine debris from simulated canal irregularities within prepared root canals. They concluded that both forms of irrigation reduced the debris score significantly. The debris score was statistically significantly lower after ultrasonic irrigation than after syringe irrigation [10]. T. Rödig, M. Sedghi, F. Konietschke, K. Lange, D. Ziebolz & M. Hülsmann compared the efficacy of syringe irrigation, RinsEndo and passive ultrasonic irrigation (PUI) in the removal of dentinal debris from simulated irregularities in root canals with different apical sizes. They found that passive ultrasonic irrigation removed debris significantly better from the artificial canal irregularities than RinsEndo and syringe irrigation [11]. Tina Rödig, Meral Bozkurt, Frank Konietschke, and Michael Hülsmann, conducted an in vitro study to compare the efficiency of conventional syringe irrigation, the Vibringe System, and passive ultrasonic irrigation (PUI) in the removal of debris from simulated root canal irregularities. Results showed that ultrasonic irrigation removed debris significantly better from the artificial canal irregularities than the Vibringe System and syringe irrigation [12]. The results of our study are in agreement with the above mentioned studies. In our study also the PUI technique was more effective than manual needle irrigation technique. The needle irrigation technique (group-1) could not clean the isthmuses effectively. This could be attributed to the formation of apical vapor lock during canal irrigation. Tay et al showed that the presence of the apical vapor lock adversely affected the debridement efficacy of needle irrigation technique [13]. The PUI technique (group-2), in this study, showed better efficiency in cleaning isthmuses. This finding suggests that ultrasonic technique activated the irrigant with sufficient force to overcome the apical vapor lock. Another reason for better performance of PUI technique may be that during ultra sonic irrigation much higher velocity and volume of irrigant flow was used in the canal.

In the third experimental group of our study, we used the Endo-Vac system. This system works on the principle of the Apical Negative Pressure (ANP) technique of irrigation [14]. The stereomicroscopic examination of Endo-Vac group revealed that in 80% of the samples apical isthmuses were filled with gutta-flow, where as isthmuses in

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middle third were filled with gutta flow in 70% of the samples **[Figure– 3]**. This was the best performance observed amongst all the experimental groups.

Benjamin A. Nielsen, J. Craig Baumgartner compared the efficacy of Endo-Vac irrigation system and irrigation needles to debride root canals at 1 mm and 3mm from working length. The result showed significantly better debridement using EndoVac compared with needle irrigation [15]. Chris Siu and J. Craig Baumgartner conducted an in vivo study to compare the debridement efficacy of EndoVac irrigation versus conventional needle irrigation. EndoVac irrigation resulted in significantly less debris at 1mm from working length compared to needle irrigation [16]. Anchu Rachel Thomas, Natanasabapathy et al. evaluated the canal isthmus debridement efficacy of new modified EndoVac irrigation protocol in comparison with EndoVac, passive ultrasonic irrigation (PUI), and conventional needle irrigation in mesial roots of mandibular molars. Intragroup analysis revealed a statistically significant difference in the percentage reduction of debris after cleaning and shaping and after final irrigation protocol in all the groups ($P < .001$). The final irrigation protocol produced significantly cleaner canal isthmuses in all the groups ($P < .001$). On intergroup analysis, the modified EVI group performed significantly better than the other groups. The EVI and PUI groups performed better than the needle irrigation group. There was no statistical significance between the EVI and PUI groups [17]. Results of our study are somewhat similar to this study. In our study for EndoVac group we used NaviTip for micro-irrigation like the modified Endovac irrigation protocol of this study.

In the present study maximum numbers of lateral canals and isthmuses were cleaned off in the EndoVac group. This could probably be attributed to the design of EndoVac irrigation system in which the micro irrigation is done upto the working length. Hence the observations of this study show that the canal isthmus debridement efficacy of EndoVac group was found to be superior to PUI and Needle irrigation. EndoVac could have performed better because of the concomitant delivery of the irrigant till the working length and effect of micro and macro-irrigation and evacuation of the irrigant creating a negative apical pressure, eliminating the apical vapour lock effect and enabling the irrigant to be pulled across the isthmus region and flushing out the debris.

CONCLUSION

Knowing the anatomic complexities of the root canal system it is important to use a suitable irrigation system while cleaning and shaping of the root canal, that will enable the irrigant delivered to flush of the debris from canal aberrations. From the observations of present study we conclude that EndoVac system fulfills the requirements of an ideal irrigation technique. However further research is needed to develop an irrigation system that will give 100% results in cleaning the root canal system.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interests.

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ABOUT AUTHORS

Dr. Ashwini Ghogare, *the post graduate student in the Department of Conservative Dentistry and Endodontics at Bharati Vidyapeeth Deemed University's Dental College and Hospital Pune, India.*

Prof. Dr. Shail Jaggi *is Professor in the Department of Conservative Dentistry and Endodontics at Bharati Vidyapeeth Deemed University's Dental College and Hospital Pune, India.*

Prof. Dr. Nitin Shah *is the Head of Department, Conservative Dentistry and Endodontics at Bharati Vidyapeeth Deemed University's Dental College and Hospital Pune, India.*

Dr. Jyoti Mandlik *is an Associate Professor in the Department of Conservative Dentistry and Endodontics at Bharati Vidyapeeth Deemed University's Dental College and Hospital Pune, India.*

Dr. Nikhil Sharma *is an Assistant Professor in the Department of Conservative Dentistry and Endodontics at Modern Dental College, Indore, Madhya Pradesh, India.*