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Comparative Evaluation Of Efficacy Of Three Irrigating Methods In Endodontic Treatment – A Confocal Laser Microscopy Study

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ABSTRACT
AIM: *To compare and evaluate the effect of different irrigation techniques i.e., conventional irrigation done using side-vented needle, passive ultrasonic irrigation (PUI), and laser assisted irrigation (LAI) on sealer penetration.*
MATERIALS AND METHODS: *A total of 30 single rooted mandibular premolars will be taken. Access cavity will be prepared and root canals will be cleaned and instrumented till working length 1 mm short of the apex. The samples will be randomly assigned into three experimental groups based on the final irrigation technique used. Group I: Irrigation using side vented needle; Group II: PUI; Group III: LAI. All the samples will be obturated using AH plus sealer and the sections will be observed under confocal laser scanning microscope to evaluate the maximum depth of sealer penetration at 3mm, 5mm and 7mm levels. Statistical analysis will be done by using one way ANOVA and Tukey's post-hoc test to compare the maximum depth of sealer penetration.*
RESULT: *In the all three groups, coronal third (sections at 7mm from root apex) showed the highest penetration depth of irrigant. Laser activation (Group 3) showed the highest penetration depth in all the three sections when compared with manual and passive ultrasonic irrigant activation. One-way analysis of variance and post hoc test showed there were significantly high differences among all the three groups and also at all three levels (P < 0.05).*
CONCLUSION: *Diode laser–assisted irrigant activation technique had better penetration depth in all the three aspects of root dentin.*
KEY WORDS:*Root Canal Irrigation, Passive ultrasonic irrigation, Laser activated irrigation, Confocal laser scanning microscope.*

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I. INTRODUCTION

The main goal of root canal treatment is to eliminate the microorganisms particularly in the apical third area and to prevent re-infection. In order to achieve these goals the instrumentation must be combined with adequate irrigation. Therefore, different irrigation methods have been proposed to deliver the irrigant to the remote areas of the root canal. The dentinal tubular penetration depth of sealer is an important factor for successful root canal treatment.

The root canal system is highly complex with extra canals, lateral canals, communications and multiple portal of exit. Micro-CT studies showed that more than 35 to 40 % of root canal surface remains untouched by instruments after cleaning and shaping procedures. For irrigation to be effective, it needs to penetrate such portions of the root canal.

Various endodontic irrigants are used effectively to disinfect these root canal complexities and dentinal tubules in root dentin. Among the endodontic irrigants, sodium hypochlorite can penetrate into the dentinal tubules up to 300 µm.[5] The penetration of sodium hypochlorite into the root dentin depends on its time, concentration, temperature, and activation technique.[6,7]

Endodontic irrigants can be activated by manual irrigation activation and irrigant activation using various devices such as sonic, ultrasonic, apical negative pressure irrigant system,[7] and plastic rotary files.[8] There are evidence in literature that ultrasonic agitation can increase the penetration depth of irrigant even in the apical third of root canal.[9] Dental lasers have unique properties such as photochemical, photoacoustic, and photothermal effects.[10] Various properties of lasers such as smear layer removal, disinfection of root canal, and postoperative pain management have been studied in literature.[11] But very limited research has been performed on diode laser as irrigant activation. Thus, the aim of this study was to compare and evaluate the penetration depth of irrigant after using manual, passive ultrasonic, and diode laser–assisted irrigant activation technique.

II. MATERIALS AND METHODS

This in-vitro study was conducted in D A Pandu Memorial R V Dental College after ethical approval from the Institutional Review Board.

A total of 30 permanent mandibular premolars extracted due to periodontal/orthodontic reasons was used in this study. The presence of single canal was verified radiographically. Teeth with immature apex, radicular resorption or an endodontic filling was rejected. Teeth were immersed in 4% NaOCl for 2hrs and any visible calculus was removed ultrasonically.

Access cavity was prepared by using No. 2 endodontic access bur. Working length was established by inserting a size 10 K file until the file tip appeared at the apical foramen and then subtracting 1mm from this length. Biomechanical preparation was done using step-back preparation. The apical preparation was done up to size 40 K- file and then step back was done. Recapitulation was achieved to the estimated working length by using size 15 K-files. During cleaning and shaping the protocol followed for irrigation included 3ml of 5.25% NaOCl, 3ml of 17% EDTA followed by 3ml of 5.25% NaOCl using a 27 gauge irrigation needle.

Experimental Groups

The specimens was broadly divided into three groups based on the final irrigation technique used.

GROUP I : Conventional irrigation using side vented needle

GROUP II : Passive ultrasonic Irrigation (PUI)

GROUP III : Laser Assisted Irrigation (LAI)

Obturation of the root canals

The sealer was manipulated consistently with the manufacturer's instructions. For analysis under the CLSM, sealer was labeled with Rhodamine B dye to an approximate concentration of 0.1%. The sealer was placed with size 30 Lentulo spiral within the root canals keeping it 1 mm above the working length, and size F3 master gutta-percha cone was coated with sealer and placed within canal at working length. The root canals were then obturated with the lateral compaction technique using an endodontic finger spreader and accessory gutta-percha cones with a 0.02 taper until the entire length of the root canal was filled. Excess gutta-percha was removed employing a heated plugger, and vertical compaction was performed 1 mm below the orifice level; then, the teeth were sealed with a temporary cement barrier and stored in an incubator at 37°C at 100% humidity to allow the complete set of the sealer.

EVALUATION

The sectioning of the samples were done after 1 week. For examining of sealer penetration depth, each specimen was sectioned perpendicular to its long axis with a diamond disc at 7 mm, 5 mm, and 3 mm from the root apex using a diamond disk (Horico Dental, Berlin) with a slow-speed (25,000 rpm) handpiece under the copious amount of water coolant to avoid friction. The specimens were then mounted onto glass slides, and the sample thickness submitted to CLSM was approximately 1.0 ± 0.1 mm thick.

Penetration depth measurement

All the sections were examined under CLSM (Leica TCS SP8, Germany) at ×20 magnification with a wavelength of 514 nm. Sealer penetration depth into the dentinal tubules was measured by Adobe Photoshop CS3 using the method described by Bolles et al. [14] Using a ruler tool on the LSM Image Browser software, the sealer penetration depth was measured in micrometers (μm) and the depth of sealer penetration was recorded.

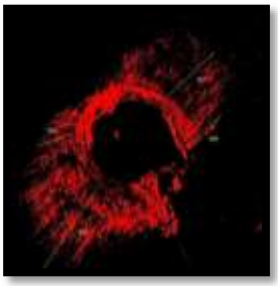
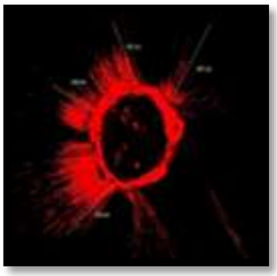
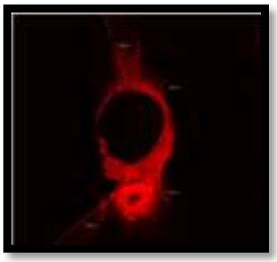
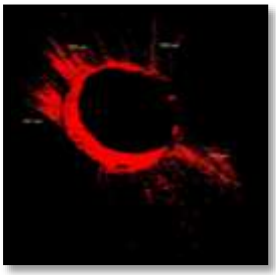
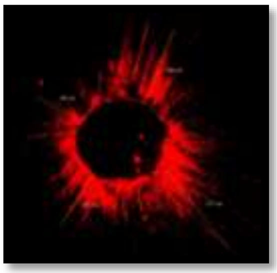
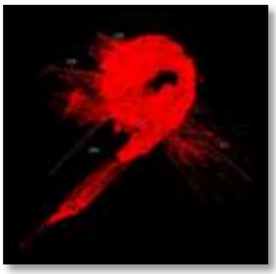
STATISTICAL ANALYSIS:

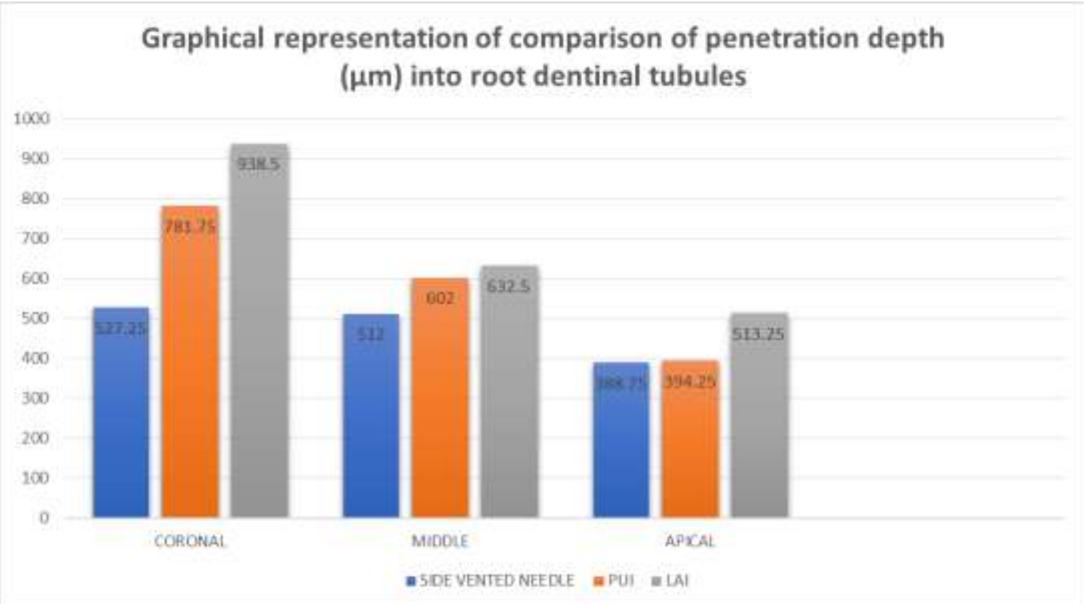
The sample size has been estimated using the GPower software v. 3.1.9.7.Considering the effect size to be measured (f) at 60% [Based on the results from the previous study done by Tushar Kanti Majumdar et al, 2021], power of the study at 80% and the alpha error at 5%, the total sample size needed was 30. Each study group comprised of 10 samples [10 samples x 3 groups = 30 samples]

One-way ANOVA test followed by Tukey's Post hoc test were used to compare the mean Depth of Sealer Penetration between the 3 study groups. The level of significance [P-Value] was set at $P<0.05$.

III. RESULTS

In the all three groups, coronal third (sections at 7mm from root apex) showed the highest penetration depth of irrigant. Laser activation (Group 3) showed the highest penetration depth in all the three sections when compared with manual and passive ultrasonic irrigant activation. One-way analysis of variance and post hoc test showed there were significantly high differences among all the three groups and also at all three levels ($P < 0.05$). Representative pictures from each group are below.

	MANUAL	PUI	LAI
CORONAL			
MIDDLE			
APICAL			



IV. DISCUSSION

The main aim of root canal treatment is to seal the root canal system to prevent re-infection [14]. The components of root canal filling includes a hard core like gutta percha and a sealer to better adapt the root canal filling material to the canal wall [15]. The sealer root canal wall interface is essential for the sealing of the root canal system as the sealer can fill the irregularities within the root canal wall and the dentinal tubules which cannot be filled by gutta percha alone [16-18].

This study evaluated and compared the effect of different irrigation methods on sealer penetration. There are many factors which influence the penetration of irrigants in the apical third of the root canal. One of the factors is the final apical preparation size. An apical preparation of ISO size 40 is adequate to accommodate sufficient irrigant volume.[19,20] Therefore, in the present study apical preparation size was standardized to a size 40/0.02. A closed end model was used to simulate the clinical procedures by sealing the apical foramen with glue.

Another factor which influences the penetration of irrigants in the apical third is the irrigant delivery method. In the present study, manual irrigation using side vented needle, PUI, and LAI was used to evaluate the sealer penetration in the apical third of the root canal.

In this study, CLSM was used to evaluate the penetration of the root canal. In contrast to SEM, CLSM allows the penetration of the root canal sealer to be evaluated in three dimensions, resulting in less artefacts in images than other methods.[24] Tedesco et al reported that CLSM allows better evaluation of the penetration of root canal sealer compared to SEM.

In CLSM analysis, a fluorescent dye is needed to ensure the sealer is visible. Previous studies have reported that Rhodamine B does not change the physical properties of sealer. [14,20] Therefore, in this study, Rhodamine B was added to the sealer to show its penetration into the dentinal tubules under CLSM. In this study, the penetration percentage of root canal sealer was higher in the coronal sections than the apical sections in all groups.

The regional differences between apical and coronal divisions can be explained by the increasing complexity of the root canal anatomy, the decrease in the number of dentinal tubules, the narrowing of the dentinal tubules towards the apical, and the increase in tubular sclerosis in the apical part. Research using SEM analysis also revealed that the apical section contained a greater amount of smear layer than the coronal section after various irrigation activation methods[20]. Therefore, further removal of the smear layer and debris in the coronal region may have allowed more sealer to penetrate into the coronal tubules. Another possible explanation for the regional differences may be that air can be compressed in the dentine surfaces when gutta-percha is inserted into the channel so that the sealer moves in the reverse direction and contact between the sealer and dentine is reduced [14,28].

To increase the penetration of root canal sealer into the dentinal tubules, it is advisable to activate irrigation solutions using different techniques and devices[2,12]. Of the various methods, Diode laser–assisted irrigant activation clearly showed the highest amount of penetration depth into the root dentin. This study is in concurrence with previous studies conducted using diode laser and various irrigants. The reason behind the better performance of diode laser is on account of its mode of delivery, the 200 μm fiber optic tip with length of 14 mm. When passive ultrasonic irrigant activation and laser–assisted activation are compared, penetration depth in ultrasonic group was found to be lesser than that of laser group. This could be attributed to the shorter contact time between ultrasonic file and root canal.

A limitation of the present study is the fact that the root canals were filled immediately after canal preparation because this is not always possible in a clinical setting, and intracanal medicament may be necessary in intermediate sessions. Over the course of several treatment visits, sealer penetration may reduce as it is not possible to remove all the medicament from the root canal.[14,32]

V. CLINICAL SIGNIFICANCE

Various anatomical complexities of dentin may limit the irrigant penetration into the dentinal tubules.

- The average number of dentinal tubules (in an area of 1 mm^2) was similar in coronal zone (46,798 ± 10,644) and apical zone (45,192 ± 10,888), while in the middle zone they were lower in number (30,940 ± 7,651).
- In the coronal zone, dentinal tubules had a greater diameter (4.32 μm) than the middle zone (3.74 μm) and the apical zone (1.73 μm).
- And hence the tubules are more densely packed in the apical zone. Therefore the removal of debris and penetration of irrigant in the apical zone was difficult and more crucial for the successful treatment outcome.

VI. CONCLUSION

Irrigation is crucial for disinfection and the quality of obturation.Under the limitations of the study it was concluded that diode laser activated irrigation showed highest depth of sealer penetration followed by passive ultrasonic irrigation and irrigation using side vented needle respectively. However the damage to periodontal ligament and alveolar socket could be reduced by lower power settings and prolonging the time of activation.

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