Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 25s (2025)
https://www.jneonatalsurg.com

In Vitro Evaluation of Smear Layer Removal with Different Methods of Activation of 17% EDTA with Ultrasonic and Laser Activation: A Scan Electron Micrscope Study

Dr. Ajil Aji Varghese[*1], Dr. R Vinaychandra[2], Dr. Shreya Shreenivas Vanaki[3], Dr Thokala Dhamodaran[4], Dr. Mrinalini Jayachandran[5], Dr Reshma Ters Antony[6]

[1*]PG student Dept. of Conservative dentistry and Endodontics, Rajarajeshwari Dental College and Hospital, Bangalore

[2]Professor and HOD Dept. of Conservative dentistry and Endodontics, Rajarajeshwari Dental College and Hospital, Bangalore.

[3]PG student Dept. of Conservative dentistry and Endodontics, Rajarajeshwari Dental College and Hospital, Bangalore.

[4]Professor Dept. of conservative dentistry and EndodonticsRajarajeshwari Dental College and Hospital, Bangalore

[5]Senior Lecturer Dept of Conservative and Endodontics Dayandasagar Dental College and Hospital

[6]PG student Dept. of Conservative dentistry and Endodontics, Rajarajeshwari Dental College and Hospital, Bangalore.

***Corresponding Author:**

Dr. Ajil Aji Varghese

PG student Dept. of Conservative dentistry and Endodontics, Rajarajeshwari Dental College and Hospital, Bangalore

Email ID: ajilputhussery@gmail.com

.Cite this paper as: Dr. Ajil Aji Varghese, Dr. R Vinaychandra, Dr. Shreya Shreenivas Vanaki, Dr Thokala Dhamodaran, Dr. Mrinalini Jayachandran, Dr Reshma Ters Antony, (2025) In Vitro Evaluation of Smear Layer Removal with Different Methods of Activation of 17% EDTA with Ultrasonic and Laser Activation: A Scan Electron Micrscope Study. *Journal of Neonatal Surgery*, 14 (25s), 389-394

ABSTRACT

Root canal therapy aims to eliminate irritants from the root canal system, and lasers are being studied as an alternative for disinfection and smear layer removal. The Er,Cr:YSGG (hard tissue) is an infrared laser that has been shown to effectively clean root canals. 17% EDTA is one of the common irrigant used for removal of smear layer by its chelating action.

This study is done for a comparative evaluation of 17% EDTA in removing smear layer with ultrasonic and laser activation (Er,Cr :YSGG) with the control group being 17% EDTA with syringe irrigation).

Keywords: *smear layer removal, ultrasonic , laser.*

1. INTRODUCTION

The primary objective of root canal therapy is to eliminate all potential irritants from the root canal system, including microorganisms, their byproducts, and remnants of pulp tissue. Research has shown that mechanical instrumentation of root canals leads to the formation of a smear layer on the dentinal walls. This layer consists of organic and inorganic dentin particles, pulp tissue remnants, microorganisms, endotoxins, and blood cells.Studies indicate that the smear layer hinders the penetration of antimicrobial irrigants, medicaments, and sealers into the dentinal tubules, potentially compromising both disinfection and the quality of the seal during treatment.[3]Furthermore, a connection has been observed between smear layer removal and enhanced periapical healing. Various techniques have been employed to eliminate the smear layer, with current approaches including chemical agents, ultrasonics, and laser irradiation[1].

Several methods for smear layer removal have been described, with chelating agents such as Ethylenediaminetetraacetic Acid (EDTA) being the most extensively studied. Research indicates that mechanical instrumentation combined with chemical irrigants alone does not fully eliminate the smear layer from the root canal walls. Therefore, additional techniques should be utilized to achieve complete removal[2].

Ultrasonic irrigant activation is one of the most commonly used adjunctive methods for smear layer removal and has been extensively compared to syringe irrigation in numerous studies. However, only a few attempts have been made to comprehensively summarize the available evidence. More recently, lasers have been explored as an alternative method for disinfecting root canals and removing smear layers and debris[9,10]. The erbium, chromium: yttrium-scandium-gallium-garnet.

(Er,Cr:YSGG) laser, an infrared laser that absorbs water, has shown potential in cleaning root canals at various power outputs ranging from 1 to 3 W[1]

The purpose of this study is to compare the efficacy of three different irrigation methods i.e syringe irrigation, ultrasonic and laser activation of 17% EDTA) in smear layer removal at coronal, middle, and apical thirds of root canal walls

2. MATERIALS AND METHODS

A total of 30 non carious single rooted premolar teeth extracted for periodontal or orthodontic purpose were collected for study. Teeth with immature apices, calcification, fracture or crack, internal/external resorption, dilacerations were excluded

Group 1: Syringe irrigation of 17% EDTA

Group 2 : 17% EDTA activated with ultra X

Group 3 : 17% EDTA activated with laser (Er,Cr:YSGG)

3. METHODOLOGY

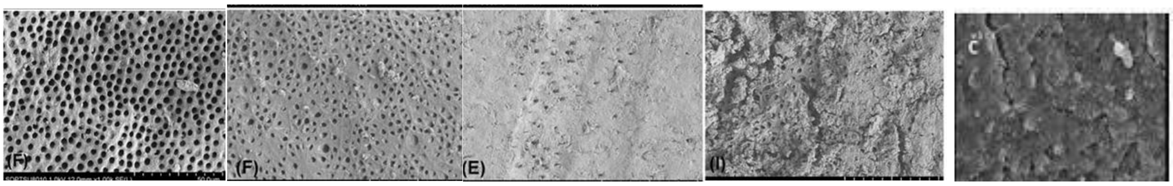
All teeth will be accessed from the coronal portion using endodontic access burs to create an entry point for instrumentation. Once access is established, the pulp chamber will be deroofed with Endo Z burs to ensure proper visibility and accessibility of the root canal system. To facilitate smooth instrumentation, a glide path will be created using a No. 10 K file with a 2% taper. The working length will be determined by inserting the K file into the canal and subtracting 1 mm from the length at which its tip becomes visible at the apical foramen.

Rotary instrumentation will then be performed up to the determined working length in a sequential manner using files of increasing size and taper. The sequence of rotary file usage will include 20 4%, 25 4%, 20 6%, 25 6%, and finally 30 6%, ensuring optimal canal shaping and preparation for subsequent irrigation and obturation.

In this study, two different activation techniques were used to enhance the effectiveness of 17% EDTA in smear layer removal. In the ultrasonic activation group(Group 2), 5 mL of 17% EDTA was delivered into the canal and subjected to intermittent ultrasonic activation for three cycles of 20 seconds each. This was followed by irrigation with 5 mL of 3% sodium hypochlorite for two minutes and a final wash with distilled water using an IrriFlex 30-gauge irrigation needle. Ultrasonic activation was performed using an Ultra X ultrasonic unit with a 21mm length 20 size, which was inserted 2 mm short of the working length to ensure optimal activation.

In the laser activation group(Group 3), 5 mL of 17% EDTA was introduced into the canal, followed by treatment with an Er,Cr:YSGG laser emitting at 2780 wavelength using a radial firing tip with a diameter of 200 µm. The laser settings included a panel output power of 1.5 W, a pulse duration of 140 µs, and a pulse frequency of 20 Hz, with a 15% water-to-air pressure ratio. The laser tip was inserted up to 2mm short of working length in the canal and moved continuously in a spiral motion from the apical to the coronal portion at a controlled speed of 2 mm/sec for three cycles. These protocols aimed to assess the effectiveness of ultrasonic and laser activation in enhancing the smear layer removal capabilities of EDTA.

Smear layer removal efficacy was checked using SEM analysis with the following scoring criteria. Torabinejad scoring system: for smear layer removal



Score 0 – No debris or smear layer present
Score 1 – Few small particles or thin smear layer
Score 2 – Debris covering less than 50 % of the root canal surface area or moderate smear layer present
Score 3 – Debris covering more than 50% of the root canal surface area or thick smear layer present
Score 4 – Heavy debris and smear layer covering the entire root canal surface

4. STATISTICAL ANALYSIS:

- Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, 7.6 7.7 NY: IBM Corp., will be used to perform statistical analyses.
- **Descriptive Statistics**: Descriptive analysis includes expression Of depth of and percentage of smear layer removal using mean and standard deviation for each group.

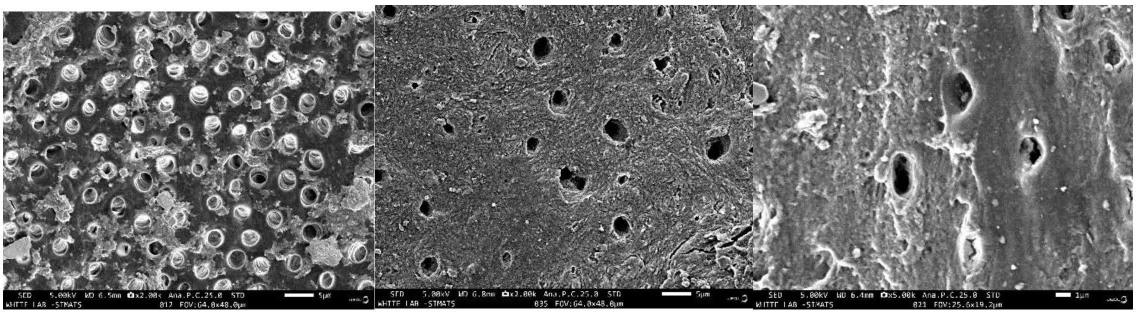
- **Inferential Statistics**: One-way ANOVA Test followed by Tukey's post hoc test will be used to compare the mean depth and percentage of smear layer removal between 3 groups. The level of significance [P-Value] will be set at P

5. RESULTS:

Comparison of Mean Smear Layer Removal Scores b/w 3 groups using kruskal wallis

Groups	N	Mean	SD	MIN	MAX	P-value
control	10	3.30	0.68	3	4	0.005
Ultrasonic	10	1.6	0.48	1	2	0.005
Laser	10	1.9	0.53	1	2	0.005

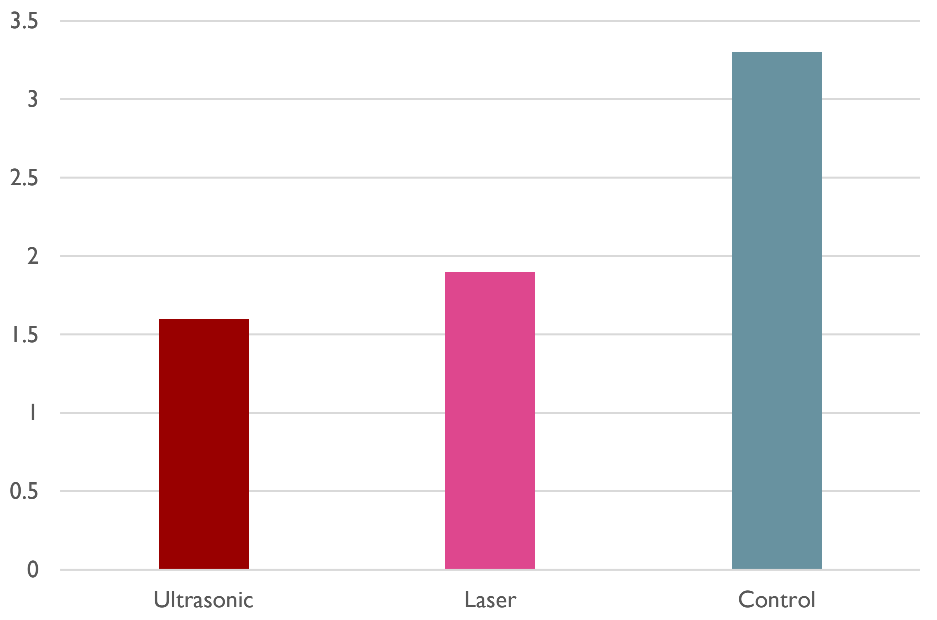
* - Statistically Significant



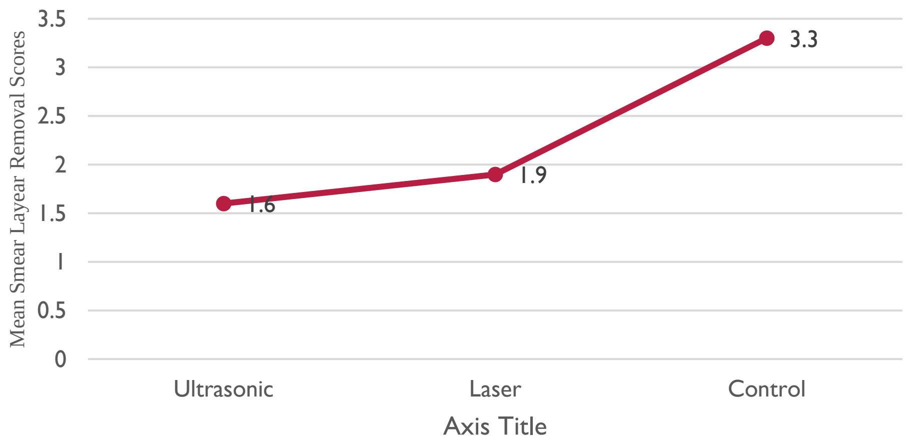
SEM images of experimental groups
Group A - Control
Group B - Ultrasonic
Group C - Laser

The mean Smear Layer Removal Scores for Control group was 3.30 ± 0.68, for Ultrasonic group was 1.6 ± 0.48 and in Laser group was 1.9 ± 0.53. There was a significant difference in the mean Smear Layer Removal Scores between 3 groups at p=0.005. Multiple comparison of mean differences in the scores between groups revealed that Control group showed significantly higher scores as compared to Ultrasonic & Laser group and the mean differences were statistically significant at p=0.002 & p=0.02 respectively. However, no significant difference in the mean Smear Layer Removal scores was observed between Ultrasonic and Laser group [p=0.47]. This infers that Ultrasonic group showed significantly lesser Smear Layer Removal Scores with better efficiency followed by Laser group with least efficiency in control group.

Graph no.1: Mean Smear Layear RemovalScoresb/w 3 groups



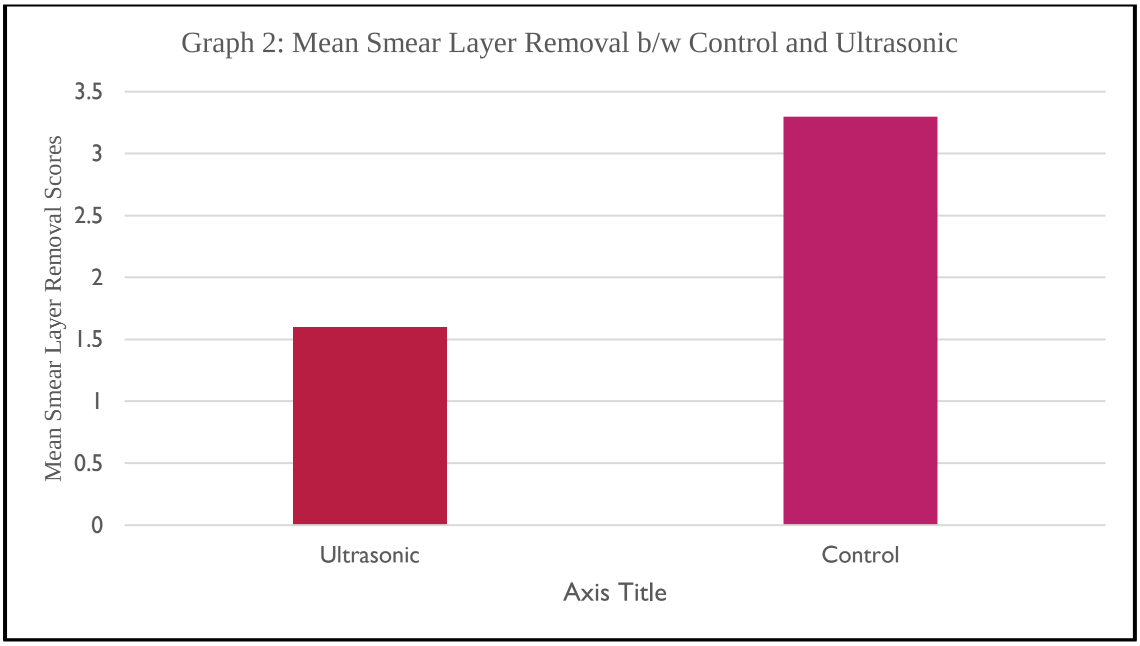
Graph no.1: Mean Smear Layear Removal Scores b/w 3 groups (Arranged in Ascending order)



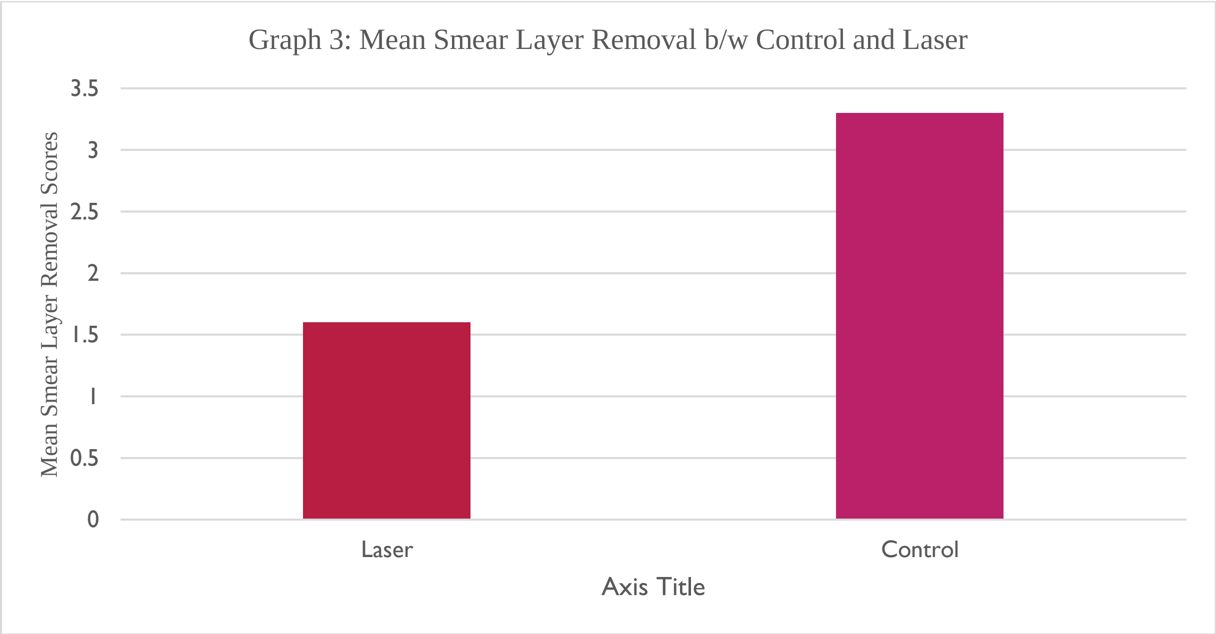
6. DISCUSSION

In this study, under recommended protocols, the control group showed a statistically significant difference compared to other groups, exhibiting a greater presence of smear plugs on the apical root dentin surface due to the vapor lock effect. Trapped air in the apical third of root canals hindered irrigant exchange, limiting its effectiveness. The use of the Irriflex needle for irrigation demonstrated greater penetrability, enhancing its efficiency. Additionally, Irriflex generated shear lateral stress, which facilitated the penetration of the irrigant into complex root canal anatomies. This improved irrigant distribution contributed to better smear layer removal and overall canal cleanliness.

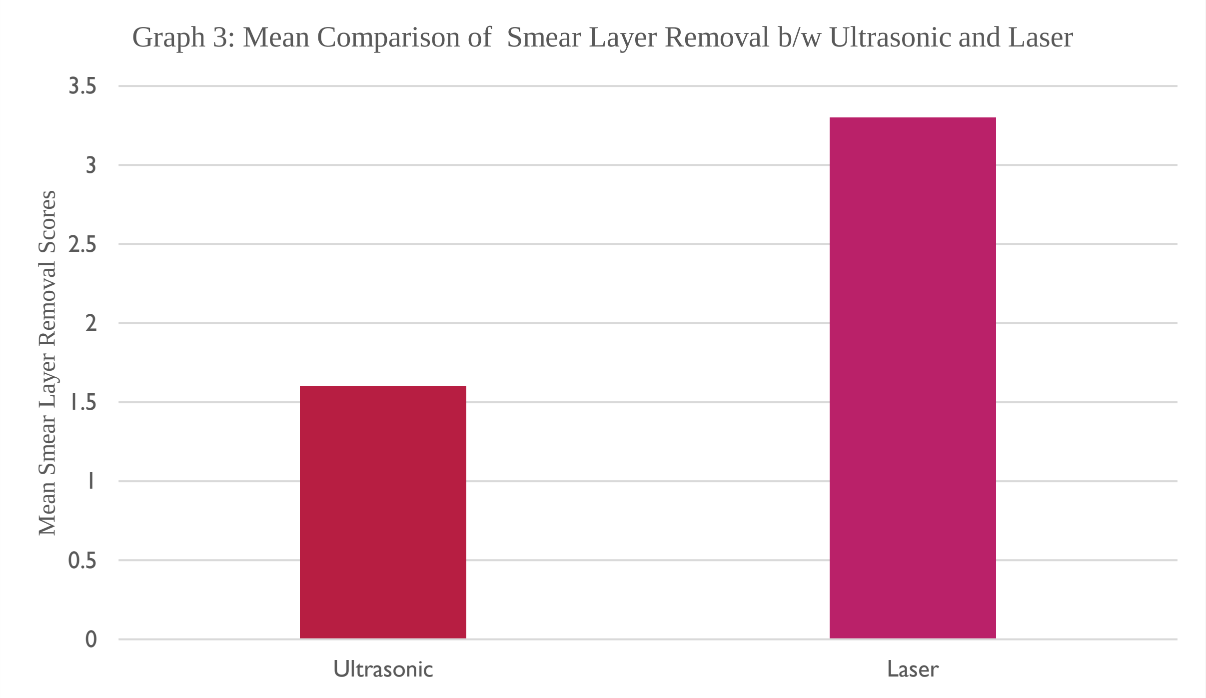
In conventional syringe needle irrigation, the irrigating solution typically extends only 1mm beyond the needle tip, primarily within the confined apical region of the canal. Ultrasonic activation was utilized exclusively after completing instrumentation to optimize the effects of acoustic streaming. A low-power setting was applied to prevent any under damage to the canal walls, ensuring a precise and controlled treatment process



In this study, the laser group showed better smear layer removal compared to the control group due to its ability to enhance fluid dynamics through photoacoustic streaming and cavitation effects, leading to better irrigant agitation and penetration. Unlike conventional syringe irrigation, which reaches only 1mm beyond the needle tip, laser activation allows deeper irrigant penetration, effectively disrupting and removing the smear layer even in narrow and complex canal areas. The cavitation effect generates microbubbles that collapse with high energy, breaking down debris and biofilm more efficiently while reducing surface tension for improved irrigant spread.



Comparing LAI and PUI, greater smear layer removal was observed in the apical part with PUI activation. However, the difference between both techniques was not statistically significant, as both enhanced smear removal by activating the irrigant. In Passive Ultrasonic Irrigation (PUI), acoustic energy is transmitted through an oscillating file or a smooth wire to the irrigant within the canal. During laser energy absorption by the irrigant solution, vapor bubbles can form, leading to a remarkable volume expansion of up to 1600 times the original volume. This is followed by a collapse that triggers acoustic streaming and, subsequently, a cavitation effect. The Er,Cr:YSGG laser at 1.5W effectively reduces the smear layer in the apical sections of root canals. Studies have examined erbium laser power levels from 1W to 6W, highlighting their impact on dentinal walls. However, high-power irradiation above 4W may cause cracks and carbonization on dentinal walls. So it is adviced to keep the power setting within 4W.



7. CONCLUSION

Our study revealed that the Er,Cr:YSGG laser was less effective in removing debris from the apical root canal walls compared to the ultrasonic group using traditional EDTA and NaOCl irrigation techniques. This highlights the importance of ultrasonic activation for thorough debris removal in root canal treatments while minimizing adverse effects on dentin. Using laser advantage sterility of the canal.

Both laser and ultrasonic irrigation techniques significantly enhance smear layer removal compared to conventional methods. Laser irrigation offers superior bacterial reduction, deeper penetration, and improved sterility within the root canal. On the other hand, ultrasonic irrigation provides enhanced debris removal, cost-effectiveness, and easy availability. The choice between these methods depends on clinical requirements, equipment accessibility, and practitioner preference. Incorporating these advanced irrigation techniques into endodontic practice can improve treatment outcomes and contribute to the long-term success of root canal therapy.

REFERENCES

[1] Bolhari B, Ehsani S, Etemadi A, Shafaq M, Nosrat A. Efficacy of Er,Cr:YSGG laser in removing smear layer and debris with two different output powers. Photomed Laser Surg. 2014 Oct;32(10):527-32. doi: 10.1089/pho.2014.3766. Epub 2014 Sep 8. PMID: 25198390; PMCID: PMC4195347.

[2] Montero-Miralles P, Torres-Lagares D, Segura-Egea JJ, Serrera-Figallo MÁ, Gutierrez-Perez JL, Castillo-Dali G. Comparative study of debris and smear layer removal with EDTA and Er,Cr:YSGG laser. J Clin Exp Dent. 2018 Jun 1;10(6):e598-e602. doi: 10.4317/jced.54936. PMID: 29930779; PMCID: PMC6005092.

[3] Căpută, P. E., Retsas, A., Kuijk, L., Chávez de Paz, L. E., & Boutsioukis, C. (2019). Ultrasonic Irrigant Activation during Root Canal Treatment: A Systematic Review. Journal of Endodontics, 45(1), 31-44.e13. doi:10.1016/j.joen.2018.09.010

[4] Kuah HG, Lui JN, Tseng PS, Chen NN. The effect of EDTA with and without ultrasonics on removal of the smear layer. J Endod. 2009 Mar;35(3):393-6.

[5] Habshi AY, Aga N, Habshi KY, Hassan MEM, Choudhry Z, Ahmed MA, Syed AUY, Jouhar R. Efficacy of Smear Layer Removal at the Apical One-Third of the Root Using Different Protocols of Erbium-Doped Yttrium Aluminium Garnet (Er:YAG) Laser. Medicina (Kaunas). 2023 Feb 22;59(3):433.

[6] Kim SY, Jang YE, Kim BS, Pang EK, Shim K, Jin HR, Son MK, Kim Y. Effects of Ultrasonic Activation on Root Canal Filling Quality of Single-Cone Obturation with Calcium Silicate-Based Sealer. Materials (Basel). 2021 Mar 8;14(5):1292.

[7] Adl A, Razavian A, Eskandari F. The efficacy of EndoActivator, passive ultrasonic irrigation, and Ultra X in removing calcium hydroxide from root canals: an in-vitro study. BMC Oral Health. 2022 Dec 3;22(1):564.