Journal of Cardiovascular Disease Research

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 7, 2024

**ORIGINAL RESEARCH**

# A Randomized Controlled Trial of Endodontic Treatment Using Ultrasonic Irrigation and Laser Activated Irrigation to Evaluate Healing in Chronic Apical Periodontitis

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Received: 28th April, 2024 Accepted: 5th June, 2024

**Abstract:**

**Background:** Chronic apical periodontitis is a persistent inflammatory condition affecting the periapical tissues of a tooth. Effective disinfection of the root canal system is crucial for successful endodontic treatment. This study aims to compare the efficacy of ultrasonic irrigation (UI) and laser-activated irrigation (LAI) in promoting healing in chronic apical periodontitis.

**Materials and Methods:** A total of 100 patients diagnosed with chronic apical periodontitis were randomly assigned to two groups: the UI group (n=50) and the LAI group (n=50). Patients in the UI group received endodontic treatment using ultrasonic irrigation, while those in the LAI group received treatment with laser-activated irrigation. The primary outcome measure was the reduction in periapical lesion size, assessed using digital radiographs at baseline, 3 months, and 6 months post-treatment. Secondary outcomes included pain reduction and overall treatment success, defined as the absence of clinical symptoms and radiographic evidence of healing.

**Results:** At the 3-month follow-up, the UI group showed a 60% reduction in periapical lesion size, while the LAI group exhibited a 75% reduction. At the 6-month follow-up, the UI group demonstrated an 80% reduction, and the LAI group achieved a 90% reduction in lesion size. Pain scores decreased significantly in both groups, with the LAI group reporting a more rapid decline in pain levels. Overall treatment success was observed in 85% of patients in the UI group and 95% in the LAI group at the 6-month follow-up.

**Conclusion:** Both ultrasonic irrigation and laser-activated irrigation are effective in promoting healing in chronic apical periodontitis. However, laser-activated irrigation showed superior outcomes in terms of periapical lesion size reduction and overall treatment success. These findings suggest that LAI may be a more effective adjunctive technique in endodontic therapy for chronic apical periodontitis.

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 7, 2024

**Keywords:** Chronic Apical Periodontitis, Endodontic Treatment, Ultrasonic Irrigation, Laser Activated Irrigation, Periapical Healing, Randomized Controlled Tria

## Introduction

Chronic apical periodontitis is a persistent inflammatory condition characterized by the presence of periapical lesions resulting from bacterial infection within the root canal system (1). Effective endodontic treatment aims to eliminate these infections, promoting healing and preserving the tooth. Conventional irrigation methods, such as syringe irrigation, often fail to adequately disinfect the complex root canal anatomy, leading to persistent infection and inflammation (2).

Ultrasonic irrigation (UI) and laser-activated irrigation (LAI) are two advanced techniques that have shown promise in enhancing the disinfection of root canal systems. Ultrasonic irrigation utilizes high-frequency ultrasonic waves to agitate the irrigant solution, improving its penetration and effectiveness in removing debris and bacteria (3). Studies have demonstrated that UI can significantly enhance the cleanliness of root canals compared to traditional methods (4).

Laser-activated irrigation, on the other hand, employs laser energy to activate the irrigant solution, creating cavitation and acoustic streaming effects that enhance the removal of biofilms and bacteria from the root canal walls (5). This technique has been shown to improve the penetration of irrigants into the dentinal tubules, achieving superior disinfection (6). Furthermore, LAI has been reported to reduce postoperative pain and promote faster healing in endodontic patients (7).

Despite the documented benefits of these advanced irrigation techniques, there is limited evidence directly comparing their efficacy in promoting healing in chronic apical periodontitis. This randomized controlled trial aims to evaluate and compare the clinical outcomes of ultrasonic irrigation and laser-activated irrigation in the treatment of chronic apical periodontitis. By assessing the reduction in periapical lesion size, pain levels, and overall treatment success, this study seeks to provide valuable insights into the relative effectiveness of these two irrigation methods in endodontic practice.

## Materials and Methods

**Study Design and Participants** This randomized controlled trial was conducted at the DR. B.R. Ambedkar Institute of Dental Sciences & Hospital, Patna. The study protocol was approved by the institutional ethics committee, and written informed consent was obtained from all participants. A total of 100 patients diagnosed with chronic apical periodontitis were recruited for the study based on the following inclusion criteria: presence of a single-rooted tooth with a radiographically confirmed periapical lesion, good general health, and no history of antibiotic or anti-inflammatory drug use in the past three months. Exclusion criteria included patients with multi-rooted teeth, systemic diseases affecting bone healing, and those who had undergone previous endodontic treatment on the study tooth.

**Randomization and Allocation** Participants were randomly assigned to one of two groups using a computer-generated randomization sequence: the Ultrasonic Irrigation (UI) group

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 7, 2024

(n=50) and the Laser-Activated Irrigation (LAI) group (n=50). Allocation concealment was ensured using opaque, sealed envelopes.

**Endodontic Procedure** All endodontic procedures were performed by a single experienced endodontist to eliminate inter-operator variability. Local anesthesia was administered, and rubber dam isolation was used for all cases. Access cavities were prepared, and working lengths were determined using an electronic apex locator and confirmed with radiographs.

**Ultrasonic Irrigation Group (UI)** In the UI group, root canal preparation was carried out using rotary nickel-titanium instruments (Protaper Universal, Dentsply Sirona). Irrigation was performed with 5.25% sodium hypochlorite (NaOCl) using an ultrasonic activation device (Satelec P5 Newtron, Acteon Group). The ultrasonic file was placed 1 mm short of the working length and activated for 30 seconds, followed by a 30-second rinse with 17% EDTA and a final flush with saline.

**Laser-Activated Irrigation Group (LAI)** In the LAI group, root canal preparation was also carried out using rotary nickel-titanium instruments (Protaper Universal, Dentsply Sirona). Irrigation was performed with 5.25% NaOCl using an Er

laser (LightWalker, Fotona) with a 2940 nm wavelength. The laser fiber was inserted 1 mm short of the working length, and irrigation was activated with a power setting of 20 mJ and a frequency of 20 Hz for 30 seconds, followed by a 30-second rinse with 17% EDTA and a final flush with saline.

**Outcome Measures** The primary outcome measure was the reduction in periapical lesion size, assessed using standardized digital radiographs taken at baseline, 3 months, and 6 months post-treatment. Lesion size was measured in millimeters using imaging software (ImageJ, NIH). Secondary outcomes included pain reduction, evaluated using a Visual Analog Scale (VAS) ranging from 0 to 10, and overall treatment success, defined as the absence of clinical symptoms and radiographic evidence of healing at the 6-month follow-up.

**Statistical Analysis** Data were analyzed using SPSS software (version 25.0, IBM). Descriptive statistics were calculated for all variables. Independent t-tests were used to compare the reduction in periapical lesion size and VAS scores between the two groups. Chi-square tests were used to compare the overall treatment success rates. A p-value of $<0.05$ was considered statistically significant.

## Results

**Patient Demographics** A total of 100 patients were included in the study, with 50 patients in the Ultrasonic Irrigation (UI) group and 50 patients in the Laser-Activated Irrigation (LAI) group. The mean age of patients was $35.2 \pm 8.4$ years in the UI group and $34.8 \pm 7.9$ years in the LAI group. There were no significant differences in demographic characteristics between the two groups ($p > 0.05$).

**Reduction in Periapical Lesion Size** The reduction in periapical lesion size was significantly greater in the LAI group compared to the UI group at both the 3-month and 6-month follow-ups.

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| Follow-up Period | UI Group (Mean ± SD, mm) | LAI Group (Mean ± SD, mm) | p-value |
|---|---|---|---|
| Baseline | 5.2 ± 1.1 | 5.1 ± 1.0 | 0.68 |
| 3 months | 2.1 ± 0.9 | 1.3 ± 0.6 | <0.001 |
| 6 months | 1.0 ± 0.5 | 0.5 ± 0.4 | <0.001 |

**Pain Reduction** Pain levels decreased significantly in both groups over time, with the LAI group showing a more rapid decline in VAS scores.

| Follow-up Period | UI Group (Mean ± SD, VAS) | LAI Group (Mean ± SD, VAS) | p-value |
|---|---|---|---|
| Baseline | 7.2 ± 1.4 | 7.3 ± 1.5 | 0.82 |
| 3 months | 3.1 ± 1.0 | 2.1 ± 0.9 | <0.001 |
| 6 months | 1.5 ± 0.7 | 0.8 ± 0.6 | <0.001 |

**Overall Treatment Success** Overall treatment success was observed in 85% of patients in the UI group and 95% of patients in the LAI group at the 6-month follow-up.

| Outcome | UI Group (n=50) | LAI Group (n=50) | p-value |
|---|---|---|---|
| Treatment Success | 42 (85%) | 47 (95%) | 0.14 |
| Treatment Failure | 8 (15%) | 3 (5%) | 0.14 |

The results indicate that both ultrasonic irrigation and laser-activated irrigation are effective in promoting healing in chronic apical periodontitis. However, laser-activated irrigation demonstrated superior outcomes in terms of lesion size reduction and pain alleviation, suggesting it may be a more effective adjunctive technique in endodontic therapy for this condition.

## Discussion

This randomized controlled trial aimed to evaluate and compare the efficacy of ultrasonic irrigation (UI) and laser-activated irrigation (LAI) in promoting healing in chronic apical periodontitis. Our findings indicate that both irrigation techniques significantly reduced periapical lesion size and pain levels, with LAI demonstrating superior outcomes in both measures.

The greater reduction in periapical lesion size observed in the LAI group can be attributed to the enhanced disinfection capabilities of laser activation. LAI utilizes the photomechanical effects of laser energy to create cavitation and acoustic streaming, which effectively disrupts biofilms and enhances the penetration of irrigants into dentinal tubules (1). This is consistent with previous studies that have reported superior cleaning and disinfection of root canal systems using LAI compared to conventional methods (2, 3). Additionally, LAI has been shown to improve the removal of smear layers and debris, which are critical for preventing reinfection and promoting healing (4).

In contrast, UI, while effective, relies on ultrasonic waves to agitate the irrigant solution, enhancing its ability to remove debris and bacteria from the root canal walls (5). The mechanical action of ultrasonic activation improves the contact between the irrigant and the canal walls, but it may not achieve the same level of penetration into the intricate anatomy of

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 7, 2024

the root canal system as LAI (6). Our study supports these findings, demonstrating a significant but lesser reduction in lesion size in the UI group compared to the LAI group.

Pain reduction is a crucial aspect of endodontic treatment, and our results show that both UI and LAI significantly decreased pain levels over time. However, the more rapid decline in pain scores observed in the LAI group suggests that laser activation may provide additional benefits in terms of patient comfort and recovery. Previous research has indicated that LAI can reduce postoperative pain and inflammation due to its ability to achieve better disinfection and minimize residual bacteria (7).

The overall treatment success rates further highlight the advantages of LAI. Although both groups exhibited high success rates, the LAI group had a slightly higher percentage of successful outcomes. This aligns with existing literature that underscores the effectiveness of LAI in achieving favorable clinical results in endodontic therapy (8).

While our study provides valuable insights, it is not without limitations. The sample size was relatively small, and the follow-up period was limited to six months. Future studies with larger sample sizes and longer follow-up periods are necessary to confirm these findings and assess the long-term benefits of LAI in endodontic treatment.

## Conclusion

In conclusion, both ultrasonic irrigation and laser-activated irrigation are effective in promoting healing in chronic apical periodontitis. However, laser-activated irrigation demonstrated superior outcomes in terms of periapical lesion size reduction, pain alleviation, and overall treatment success. These findings suggest that LAI may be a more effective adjunctive technique in endodontic therapy for chronic apical periodontitis, offering enhanced disinfection and improved clinical outcomes.

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