Original Article

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Effect of low-level laser therapy on pain perception and anxiety levels in conventional local anesthesia injection

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Background: The goal of dental practice is to ensure painless treatments. This study aimed to assess the effectiveness of Low-level Laser Therapy (LLLT) in reducing pain perception and anxiety associated with conventional local anesthetic injections.
Methods: This was a randomized, single-blind, split-mouth study involving 36 participants divided into two groups. Group I underwent LLLT prior to local anesthesia injection, whereas Group II underwent the procedure without laser activation. Anxiety levels were measured using the Hamilton Anxiety Rating Scale (HAM-A), and pain was evaluated using the Visual Analog Scale (VAS) and Wong–Baker Faces Rating Scale (WBFRS).
Results: Statistical analyses were performed using the SPSS 22 software (IBM, Armonk, NY, USA). Post-intervention analysis of the HAM-A scores showed a reduction in anxiety levels following LLLT, with mild anxiety increasing from 52.8% to 69.44%, and moderate anxiety decreasing from 47.2% to 30.56%. In terms of pain assessment, VAS scores revealed that 38.9% of patients in Group I reported no pain compared to 0% of patients in Group II. Moderate pain was reported by 50% of patients in Group I and 75% of patients in Group II, while severe pain was reported by 11.1% and 25% of patients, respectively. Pain distribution (WBFRS) showed that 63.9% of patients in Group I reported no pain versus 0% of patients in Group II. Little pain was experienced by 36.1% of Group I and 58.3% of Group II patients, whereas 41.7% of Group II patients reported slightly more pain. Statistical comparison showed that Group I had significantly lower mean VAS (1.72 ± 0.659) and WBFRS (1.36 ± 0.487) scores than Group II (VAS: 2.25 ± 0.439; WBFRS: 2.42 ± 0.500), with both results being statistically significant ($P < 0.001$).
Conclusion: LLLT was effective in reducing pain associated with injections. It can be used successfully to manage procedures that patients commonly perceive as painful, thereby providing a natural analgesic effect. Additionally, LLLT contributes to creating positive treatment experiences, which play a key role in fostering a long-term, trusting relationship between the patient and clinician.

Keywords: Anxiety; Local Anesthesia; Low-level Laser Therapy; Pain Perception.

INTRODUCTION

Pain management in dentistry is a significant challenge. Adequate local anesthesia is a fundamental component of modern dental practice. Patients often delay or avoid dental appointments primarily because of needle anxiety, discomfort, and the risk of injection-related injuries, such as pain, swelling, and bruising [1]. Adequate pain control not only improves the immediate experience of patients

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but also has long-term benefits for their overall attitude toward dental care. When patients experience less pain during dental procedures, they are less likely to develop fear and anxiety regarding future dental visits [2]. This experience helps to build a positive attitude and enhance cooperation between the dentist and patient, which can last for a lifetime [3,4].

Anxiety in adults during dental treatment stems from various sources. Understanding these factors is essential for effective management and mitigation of anxiety. Negative experiences with dental procedures can lead to anxiety [5]. Some patients naturally become more anxious or sensitive to new experiences. Their inherent personality traits make them more susceptible to feeling nervous in unfamiliar or potentially uncomfortable situations, including during dental visits [6].

Various methods can help reduce the pain associated with local anesthesia, including pre cooling [7], warming of the anesthetic solution [8,9], adjusting needle size [10], applying topical gel [11], reducing injection speed [12], using vibratory instruments [13], and laser therapy [14]. Photobiomodulation therapy (PBMT), often referred to as LLLT, has attracted increasing interest in dentistry because of its broad range of therapeutic applications, including pain reduction, dentinal hypersensitivity management, wound healing acceleration, and analgesia. It enhances ATP production [15], improves cell metabolism [16], and reduces pain and inflammation by modulating prostaglandin and bradykinin synthesis. It enhances acetylcholinesterase activity, promotes vasodilation, and improves tissue fluid flow [17].

LLLT is a nonthermal light therapy with several documented benefits, including pain and inflammation reduction, immunomodulation, and tissue regeneration. LLLT employs coherent, monochromatic light at a specific wavelength to initiate photobiostimulation, triggering biological responses at the cellular and tissue level. When light is absorbed by cellular photoacceptors, it triggers a series of cellular responses, including cell proliferation, protein synthesis, vasodilatation, and the activation of various signaling pathways. For therapeutic effects, the optimal laser wavelengths typically range from 600 to 1000 nm in the red to near-infrared spectra, with energy densities of up to 10 J/cm^2 applied to the target sites. These parameters have been shown to effectively stimulate biological processes and are considered potential applications of LLLT in reducing pain perception during injections in periodontal therapy [18]. Therefore, this study aimed to evaluate the effects of low-level laser therapy administered before needle insertion in an adult population, specifically to assess its potential of reducing the pain associated with local anesthetic injections.

METHODS

The present study was a randomized, single-blind, split-mouth study conducted with 36 participants divided into two groups. Group I underwent LLLT prior to local anesthesia injection, whereas Group II underwent the procedure without laser activation. Study participants were recruited from the Department of Periodontology, SIBAR Institute of Dental Sciences, Takellapadu, Guntur, Andhra Pradesh, India. This study was approved by the institutional ethics committee (Pr. 351/IEC/SIBAR/2024), and registered under the Clinical Trial Registry of India (CTRI/2024/10/075310). The study was conducted from April 2024 to May 2024. All participants provided written informed consent before enrolment. This study included 36 healthy participants of 35–45 years of age of both sexes diagnosed with periodontitis.

Sample size estimation: The G*Power 3.1.9.2 software was used to calculate the sample size based on an effect size of 0.6, a significance level of 0.05, and a power of 80%, yielding 36 participants. This study included healthy participants requiring bilateral periodontal therapy. Participants were excluded if they presented with oral lesions, such as aphthous ulcers, at the intended injection sites; any use of analgesics or corticosteroids 48 h before the study; allergy to lidocaine and epinephrine; photosensitivity allergy; pregnancy or lactation; drug and

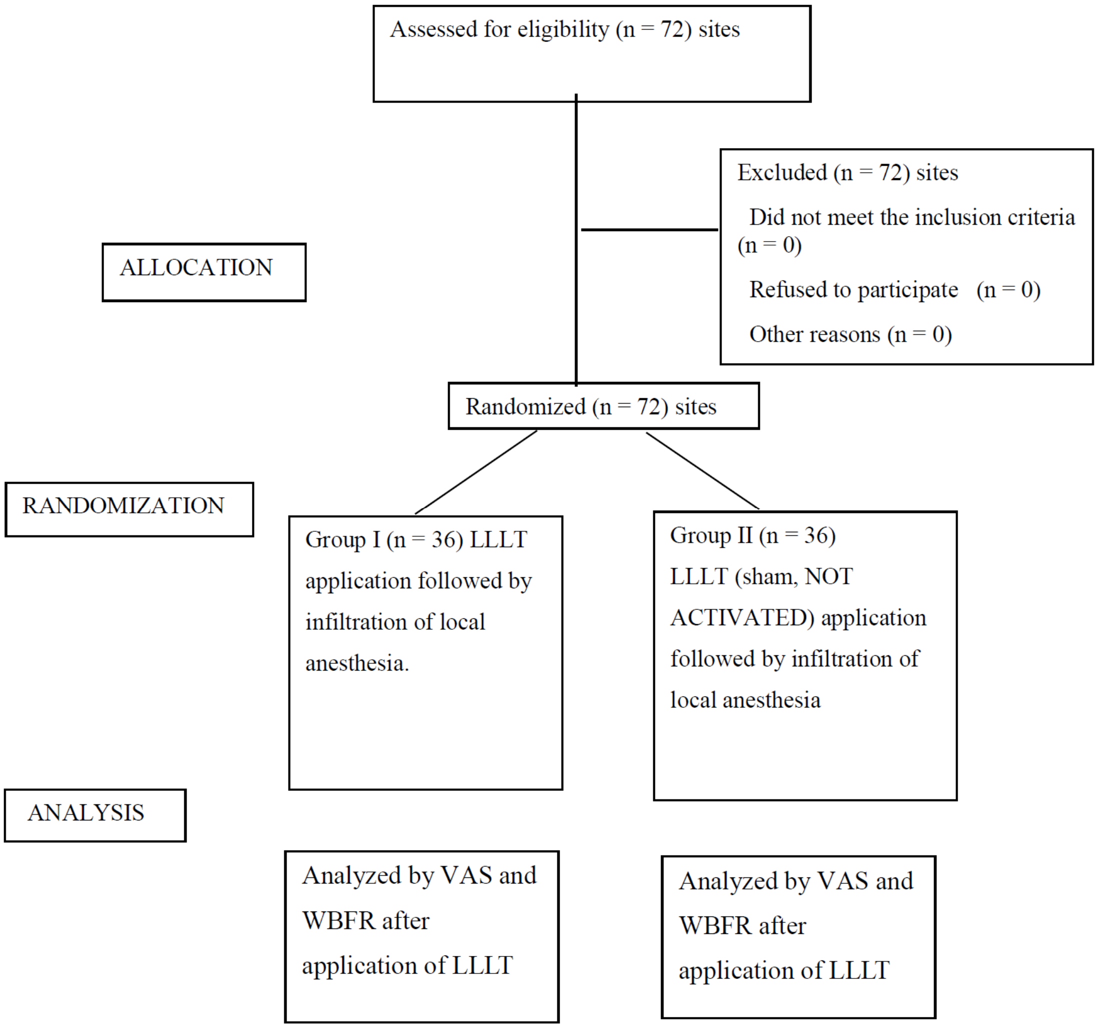

Fig. 1. Consolidated Standards of Reporting Trials (CONSORT) flow diagram of the study. LLLT, low-level laser therapy; VAS, visual analog scale; WBFR, Wong-Baker Faces Rating Scale.

alcohol abuse; or tobacco use. A CONSORT flow diagram illustrating participant allocation is shown in Figure 1.

1. Evaluation criteria

Anxiety levels were assessed using the Hamilton Anxiety Rating Scale (HAM-A), a clinician-administered tool comprising 14 items. Each item is scored on a scale of 0 (not present) to 4 (severe), yielding a cumulative score ranging from 0 to 56. Based on the total score, anxiety was categorized as mild (< 17), moderate (18–24), or severe (25–30) [19]. Pain intensity was evaluated using two validated subjective scales: the Visual Analog Scale (VAS) and the Wong– Baker Faces Rating Scale (WBFR). On the VAS, the participants marked their pain along a 10-cm line, where 0 indicated no pain and 10 indicated the worst possible pain. Scores from 1 to 5 denote mild pain, 5–10 indicate moderate pain, and 10 indicates severe pain [20]. The WBFR allowed the participants to select facial expressions that best matched their level of discomfort. Each face corresponded to a numerical value: 0 (no hurt), 2 (hurt a little bit), 4 (hurt a little more), 6 (hurt even more), 8 (hurt a whole lot), and 10 (hurt worst) [21].

2. Procedure

Participants undergoing bilateral maxillary periodontal therapy were assigned to two groups consisting of 72 sites

Fig. 2. Clinical procedure showing Low-level Laser Therapy (LLLT). (A) Diode Laser, (B) Laser not activated on control site, (C) Local anesthesia injection on control site, (D) Laser activated on test site, (E) Local anesthesia injection on test site

Table 1. Demographic characteristics

		Group I (n = 18)	Group II (n = 18)	P-value
Gender	Male	8 (38.8%)	10 (44.44%)	0.73
	Female	10 (61.1%)	8 (55.55%)	
Age	Mean ± SD (35-45)	39.77 ± 1.18	38.11 ± 1.16	0.001

Table 2. Descriptive statistics of the Hamilton Anxiety Scale

Score	n = 36 Before	Percentage (%)	N = 36 After	Percentage (%)
Mild	19	52.8%	25	69.44%
Moderate	17	47.2%	11	30.56%
Severe	0	0	0	0

Table 3. Descriptive statistics of the VAS score

Groups		VAS score				Total
		No pain	Moderate pain	Severe pain	Worst pain	
Group 1	n (%)	14 (38.9)	18 (50)	4 (11.1)	0 (0)	36 (100)
Group 2	n (%)	0 (0)	27 (75)	9 (25)	0 (0)	36 (100)

n- percentage; Mann–Whitney U test, P < 0.001; VAS, visual analog scale.

using the coin-toss method. In the test site (group I, n = 36), LLLT was administered at the injection site in activated mode, whereas in the control site (group II, n = 36) LLLT was administered on the injection site without activated mode. Participants were asked to fill out a questionnaire consisting of the HAM-A to assess anxiety; the needle was inserted into the vestibular oral mucosa and was pre-treated with a diode laser (Woodpecker LX 16) using a handpiece of 0.5 cm^2 spot size at 650 nm wavelength, with 5/J of energy for 25 s at a distance of 1 mm continuously on the test site. The laser probe was placed in the vestibule without activation mode in the control site. For safety, laser irradiation was performed using protective eyewear. Subsequently, 2% lidocaine with epinephrine was injected with a conventional needle at a speed of 1 mL/min by the operator in both groups, and the same syringe and injection technique was used for all participants to maintain standardization (Fig. 2). Participants' pain perception during the injection was assessed through self-reported scores using the VAS and WBFR after the local anesthetic injections, and their experiences were recorded at both the test and control sites. Anxiety levels were recorded.

3. Statistical analysis

Statistical analyses were performed using SPSS version 22 (IBM Corp., Armonk, NY, USA). Age was compared using an independent t-test and sex distribution was analyzed using the chi-square test. Descriptive statistics, including means and standard deviations, were calculated for the HMA-A, VAS, and WBFR in both groups. To compare the outcomes between two independent groups, an independent sample t-test was used for data that followed a normal distribution. For variables not meeting the assumption of normality, appropriate nonparametric tests, such as the Mann–Whitney U test, were used. A P-value of < 0.001 was considered statistically significant for all comparisons.

Table 4. Descriptive statistics of the WBFR scale

Groups		WBFR score						Total
		No hurt	Hurts little bit	Hurts little more	Hurts even more	Hurts whole lot	Hurts	
Group 1	n (%)	23 (63.9)	13 (36.1)	0 (0)	0 (0)	0 (0)	0 (0)	36 (100)
Group 2	n (%)	0 (0)	21 (58.3)	15 (41.7)	0 (0)	0 (0)	0 (0)	36 (100)

n-percentage; Mann–Whitney U test, P < 0.001; WBFR: Wong–Baker Faces Rating.

Table 5. Comparison of mean VAS and WBFRS scores between study groups

Parameters	Group	n	Mean	Std. deviation	Std. mean error	P-value
VAS	Group - I	36	1.72	0.659	0.110	0.001*
	Group - II	36	2.25	0.439	0.073	
WBFRS	Group - I	36	1.36	0.487	0.081	< 0.001*
	Group - II	36	2.42	0.500	0.083	

Mann–Whitney U test; *statistically significant difference (P < 0.001)
VAS, visual analog scale; WBFRS, Wong–Baker Faces Rating Scale.

RESULTS

Table 1 shows the demographic characteristics of Group I (n = 18), including 7 males and 11 females, while in Group II (n = 18), there were 8 males and 10 females with no significant differences in sex (P = 0.73). The ages of both groups fell within the 35–45 years age range and were statistically significant (P < 0.001). Table 2 presents the descriptive statistics of HAM-A scores, which decreased following LLLT. The number of participants with mild anxiety increased from 19 (52.8%) before the intervention to 25 (69.44%), whereas the number of those with moderate anxiety decreased from 17 (47.2%) to 11 (30.56%). This shift indicated an overall reduction in anxiety levels post-intervention.

Table 3 shows descriptive statistics of the VAS score in Group 1: 38.9% of participants reported no pain, 50% experienced moderate pain, and 11.1% had severe pain, with no cases of worst pain. In Group II, none reported any pain, while 75% experienced moderate pain and 25% had severe pain, with no cases of worst pain.

In Group I, 63.9% of the participants reported no pain, while 36.1% experienced little pain, with no cases of higher pain levels (Table 4). In Group II, none reported pain, 58.3% experienced little pain, and 41.7% reported slightly more pain, with no cases of higher pain levels.

Table 5 compares the mean pain scores between the two groups. For the VAS scores, Group 1 had a mean of 1.72 with SD ± 0.659, while Group II had a higher mean of 2.25 with SD ± 0.439, with the difference being statistically significant (P-value < 0.001). For the WBFRS scores, Group 1 had a mean of 1.36 with SD ± 0.487, while Group II had a higher mean of 2.42 with SD ± 0.500, with the difference being statistically significant (P-value < 0.001).

DISCUSSION

Pain is one of the most distressing experiences for individuals. In dentistry, administering local anesthesia is crucial for alleviating anxiety and ensuring patient comfort during procedures. Therefore, effective pain management during the procedure is important for successful treatment. The anticipation of a needle prick is commonly associated with pain, which further increases preprocedural anxiety. Therefore, efforts should be made to minimize pain in order to enhance patient comfort and reduce anxiety [22].

The present study analyzed the impact of LLLT with local anesthetic injection on pain and anxiety levels in adults undergoing maxillary bilateral periodontal therapy. The participants were divided into two groups, with a total of 72 injection sites (n = 36 sites per group). In Group I, LLLT was administered in the activated mode at the injection site, whereas in Group II LASER was applied without activation. Pain was subjectively evaluated using the VAS and WBFRS, which were chosen for simplicity, reliability, and applicability. The evaluation of pain using patient-reported measures is broadly recognized as the most reliable and clinically accepted approach for assessing pain. These results support the effectiveness of LLLT as an adjunct technique for minimizing injection-related discomfort. The analgesic effect of LLLT occurs by modifying nerve firing frequency, reducing nociceptive signals from peripheral nerves, and minimizing pain transmission. It inhibits A-delta and C fibers, slows conduction velocity, lowers action potential, and suppresses neurogenic inflammation, leading to effective pain relief [23,24].

Kulekcioglu et al. (2003) evaluated the therapeutic role of LLLT in patients with temporomandibular disorders and observed notable improvements in pain, joint movement, and tenderness, supporting its utility in musculoskeletal and orofacial conditions [25]. Kreisler et al. (2004) conducted a double-blind randomized study to assess postoperative pain after endodontic surgery and concluded that laser therapy contributed to significant pain reduction during the recovery period [26]. Similarly, Arslan et al. (2017) and Naseri et al. (2020) highlighted the potential of LLLT in alleviating postoperative discomfort after root canal retreatment. The results of the present study are in accordance with the above-mentioned clinical studies exploring the benefits of LLLT in various dental procedures. These findings also highlight the potential utility of LLLT as a supportive measure in routine dental practice [27,28]. Ghabraei et al. (2018) explored the effect of photobiomodulation (PBM) on the depth of anesthesia during inferior alveolar nerve block and reported a reduction in the need for supplemental injections, reflecting an enhanced anesthetic efficiency [29]. In a split-mouth study, Jagtap et al. (2019) compared active and inactive laser applications before local anesthesia and demonstrated that LLLT significantly reduced perceived pain. This supports our present findings, in which LLLT was associated with lower pain scores during injection [30].

Ghabraei et al. (2020) and Sheriff et al. (2022) investigated the effects of LLLT on injection-related pain before local infiltration. Pain levels were assessed with VAS. Their results showed that LLLT offers advantages in routine clinical practice. The findings of Ghabraei et al. and Sheriff et al. were consistent with those of the present study [31,32]. Shekarchi et al. (2022) and Uçar et al. (2022) used LLLT as a viable alternative to topical anesthesia for pain relief without pharmacological agents. Pain levels were assessed using the WBFR. The findings of Shekarchi et al. and Uçar et al. are consistent with present study results [33,34]. Khan et al. (2023) conducted a split-mouth study to compare and evaluate pain perception in pediatric patients (6–13 years old) using PBM. VAS and WBFR were used to assess pain levels. Pain was assessed using the VAS and WBFRS. Patient compliance was recorded after the procedure. PBM has proven to be the most effective method for reducing injection pain, showing superior efficacy over other techniques. The results of the present study are in line with those of Khan et al. [35]. Abduljalil et al. in 2023 conducted a study to investigate whether PBMT enhanced analgesia during root canal treatment. Pain levels were evaluated with VAS. The findings indicated that pre-anesthesia laser irradiation reduced discomfort and the need for additional injections during root canal therapy. The results of Abduljalil et al. are in agreement with those of the present study [36]. Zandi et al. in 2024 evaluated PBMT's effects on infiltration anesthesia. Pain perception was assessed using VAS, which demonstrated a significant reduction in pain with PBMT. The results of the present study corroborated with those of Zandi et al. [37]. Helali et al. in 2025 conducted a study on transcranial photobiomodulation therapy (tPBMT) on patients with substance dependence undergoing methadone maintenance treatment . Anxiety levels were assessed using the HAM-A, and it was concluded that tPBMT significantly reduced anxiety after treatment. Our present study results align with those of Helali et al. [38].

To our knowledge, this is the first study to evaluate the use of LLLT with a diode laser before injection to assess anxiety and pain in adults. Future studies should explore various laser parameters and include different regions of the jaw to further validate and expand these findings. Emerging evidence also suggests that LLLT, when used before or in combination with topical anesthesia, can lower perceived pain scores and improve patient cooperation. Future protocols may consider this integrated approach as a practical, noninvasive strategy to enhance patient experience during local anesthesia administration.

Few limitations of this study include the use of only one diode laser setting and the assessment of a single-jaw region. Future research should also consider incorporating a dental-specific anxiety scale alongside the HAM-A to enhance the specificity of procedural anxiety measurements while retaining a comprehensive evaluation of general anxiety levels.

In conclusion, LLLT is an effective, noninvasive approach to reduce pain and anxiety and provides a natural analgesic effect. Dental treatments should aim to be as painless and stress-free as possible, while minimizing both anxiety and discomfort. The present study reinforces the role of LLLT as a conservative approach that significantly reduces pain associated with local anesthetic injections. Such positive treatment experiences help foster a long-term, trusting relationship between the patient and clinician, encouraging better cooperation and a more positive attitude toward dental care.

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Kishore Kumar Katuri: Data curation, Formal analysis, Methodology, Project administration, Supervision, Validation, Writing - review & editing
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Ramanarayana Boyapati: Conceptualization

CONFLICT OF INTEREST: The authors have no conflicts of interest to declare.

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