ORIGINAL RESEARCH

Effect of Photobiomodulation on the Depth of Local Anesthesia during Endodontic Treatment of Teeth with Symptomatic Irreversible Pulpitis

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Abstract

Aim: To determine whether photobiomodulation (PBM) therapy could increase the depth of analgesia during endodontic therapy of teeth affected with symptomatic irreversible pulpitis.

Materials and methods: Forty-nine patients with symptomatic irreversible pulpitis were randomized into two groups. In the laser group, before administering anesthesia, the lower molars' crowns were continuously treated with a diode laser (980 nm) for 20 s with a low-level laser tip in the buccal aspect close to the gingival margin. While the teeth of the second group who was blinded to the type of treatment received placebo treatment wherein the laser device was switched off. The visual analogue scale (VAS) was used to assess pain in both groups before the endodontic procedure, during dentin cutting, and at dropping pulp, wherein, the success was defined as no or mild pain. The Chi-square and independent sample *t*-tests were used to assess the data.

Results: During dentin cutting and pulp dropping, the group receiving the laser therapy presented with less mean pain score than the placebo group which was statistically significant. Additionally, it was observed that the need for supplementary injection was less frequent in the laser-treated group than in the placebo group ($p = 0.01$).

Conclusion: The irradiation by diode laser (980 nm) prior to administration of local anesthesia appears to be useful in minimizing discomfort and additional injection during root canal therapy (RCT).

Clinical Significance: Pain management is essential for providing the best possible treatment to patients before, during, and after endodontic therapy. Adequate pain control during treatment also aids in reducing postoperative discomfort. This implies the need for additional methods to reduce discomfort during endodontic treatment; hence, adjuncts are crucial to achieving this goal. Photobiomodulation may be used as an adjuvant to reduce discomfort and supplementary injections during RCT.

Keywords: Block anesthesia, Diode laser (980 nm), Endodontics treatment, Photobiomodulation, Visual analog scale.

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Introduction

Dental anxiety and phobia of dental procedures can lead to poor oral health and delay of dental care, which can occasionally lower the quality of life associated with oral health.[1] A significant link between painful experiences during dental treatments as a child and anxiety from dental procedures as an adult has been continuously reported over a period of time.[2,3] Moreover, it is reported that anesthesia injection increases patients' anxiety and fear, particularly in younger patients.[4] According to research, the effectiveness of anesthesia is not deep enough; therefore, obtaining adequate anesthesia in the inferior alveolar nerve block is occasionally necessary for mandibular teeth with symptomatic irreversible pulpitis. Since nerve block anesthesia has the advantage of using less anesthetic overall and producing less discomfort for the patient. Even so, it has the drawback of being more challenging to administer.[5]

On the contrary, low-level lasers have analgesic and anti-inflammatory properties and can block nerve impulse conduction.[6] It is demonstrated that in nerve fibers A-delta and C, laser irradiation has been shown to inhibit axonal signal transmission. It is thought that laser radiation minimizes nociceptive signal transmission because the fibers convey nociceptive impulses to the spinal cord, which therefore reduces the perception of pain.

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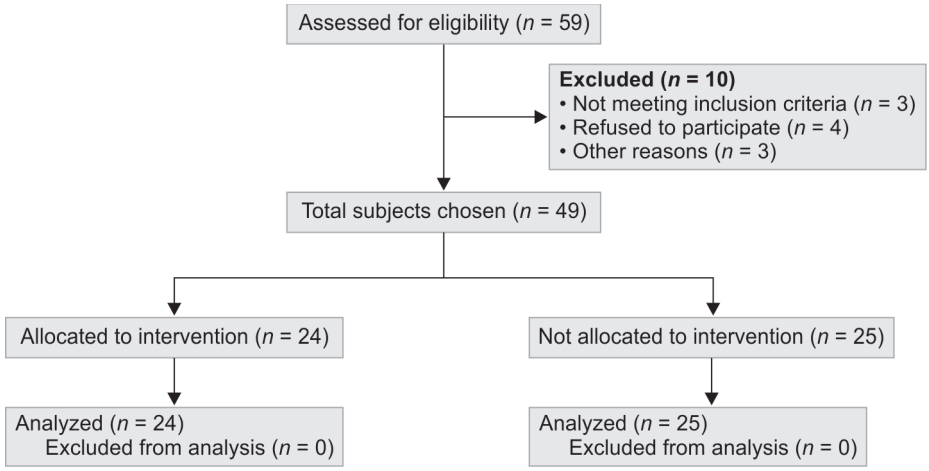
Laser treatment via photobiomodulation (PBM), also known as low-level laser light therapy (LLLT) since it is based on the use of lasers (or LED light) that emits low-intensity light, is noninvasive and has been shown to decrease inflammation and give pain relief.[7]

Flowchart 1: CONSORT flow diagram of the study



In endodontic therapy, local anesthetic is utilized to relieve pain and provide comfort to patients. However, because local anesthesia is not always attainable during endodontic treatment procedures, practitioners are constantly on the lookout for newer techniques, equipment, and anesthetic solutions.[8]

Photobiomodulation has not been used frequently in dentistry as an adjuvant to anesthesia. However, it has been proven useful in lowering pain during root canal therapy (RCT).[9] In addition, studies have proposed that pain management for post-endodontic treatment is to be successful when utilizing PBM therapy.[10–12] Photobiomodulation can thus be used in conjunction with anesthetic to alleviate discomfort during and after dental procedures. Based on the foregoing facts, as well as the fact that there is limited evidence to support the effect of PBM on the depth of local anesthesia during root canal treatment and that no similar studies have been conducted in the Sudanese population, this investigation aims to verify the effect of PBM therapy on the depth of anesthesia during endodontic therapy of teeth affected with symptomatic irreversible pulpitis in a group of Sudanese patients and to compare the visual analogue scale (VAS) and intensity of pain between patients who received and did not receive laser therapy.

Materials and Methods

The present study was a blinded, prospective, single-center randomized controlled trial with a 1:1 allocation ratio. The study protocol was approved by The Sudan University of Science and Technology's Ethics Committee (Ref. 2022/3). The CONSORT guidelines were followed (Flowchart 1). The research was carried out between March and August of 2022. The goal of the study was described to the participants, and signed informed consent was acquired.

Selection of Patients

Forty-nine individuals who reported symptoms of toothache to the Omdurman Military Hospital's Department of Endodontics between March 2022 and August 2022 and required endodontic therapy for their lower right or left molars were recruited for the present study. The patients who met the following criteria were selected—mandibular permanent molars with irreversible pulpitis confirmed by tooth percussion (which involved gentle tapping on the tooth), X-ray (preoperative radiographs), history of spontaneous pain, teeth with healthy gums (probing depth no more than 3 mm), pulpal exposure limited to the tooth's occlusal side, and patients who had not used systemic antibiotics in the previous 24 hours. In contrast, patients on psychiatric medicine, pregnant women, patients with cancer, patients with mouth lesions, and patients with dentinal sensitivity were all excluded from the present research.

Randomization Process

Before the initiation of the treatment, the study's objectives were described to the patients, and their signed consent was taken. The selected patients (49) were randomly allocated to either the laser or placebo groups through a simple randomized procedure. A box was created to hold 49 folded pieces of paper, twenty-four labeled "Laser Group" and the other twenty-five labeled "Placebo Group" those who did not receive laser treatment. Each participant was instructed to choose one folded piece of paper from the box and was then allocated to one of the two groups. The patients were blinded in this trial.

Data Collection

Following the clinical examination, preoperative radiographs were obtained for all participants. After explaining the concept of pain, patients were asked to record the Heft-Parker VAS scores before the start of the endodontic procedure (VAS0) as defined previously by Delgado.[13]

Laser Application Protocol

For the PBM treatment in the laser group, the teeth were irradiated with a diode laser (980 nm) Quicklase (Quicklase®). The output power was 0.8 watts (15 J/cm^2 energy) with a 20 s duration and 100 Ms intervals. Just prior to administering anesthesia, the lower molars' crowns were continuously treated for 20 s with a low-level laser tip in the buccal aspect close to the gingival margin. During the process of irradiation, both practitioners and patients wore safety glasses to avoid laser irradiation hazards. The placebo group's teeth received no laser treatment (the laser equipment was turned off). The inferior alveolar nerve block was performed with 2% lidocaine hydrochloride and 1/80000 epinephrine in a standard location. The criteria for determining that the anesthesia was profound was lip numbness. While performing the treatment for each group, the evaluation was repeated and the VAS was recorded during cavity access preparation (dentin cutting VAS1) and at entry into

Table 1: Demographic data of the patients in the two groups

	Laser group	*Placebo group*	*p-value*
Age	29.9 ± 7.1	30.5 ± 6.9	0.5
Gender			
Male	20	19	0.2
Female	5	5	
Preoperative pain	143.20 ± 19.82	143.20 ± 19.82	1.000

Table 2: Comparison of VAS0, VAS1, and VAS2 in the two groups

Grouping	*Laser*	*Placebo*	*p-value*
VAS 0	Mean ± SD		1.000
	143.20 ± 19.82	143.20 ± 19.82	
VAS 1	Mean ± SD		0.010*
	43.20 ± 9.85	72.60 ± 16.97	
VAS 2	Mean ± SD		0.001*
	50.40 ± 8.04	85.00 ± 0.00	

*p-value significant between VAS1 and VAS2

the pulp (VAS2). The patients were informed to fill the VAS cards at different stages, that is, before the endodontic procedure, during dentin cutting, and during pulp dropping. The applied process was successful if patients reported mild to no pain throughout the access cavity preparation (VAS score ≤54) suggesting that no additional injections were required. However, anesthesia failure was documented when patients reported mild-to-severe discomfort during access cavity preparation. As a result, additional steps were performed to inject supplemental anesthetic (articaine 4% epinephrine 1/200000 EXIR) for infiltration or intrapulpal injection. The endodontic treatment was completed in all the patients of both groups by a single investigator alone. The data at three different time intervals was recorded, tabulated, and statistically analyzed.

Statistical Analysis

The Statistical Package for Social Science (SPSS v.26) was utilized for data analyses. To look for normality in the data Shapiro-Wilk test was applied. The Chi-square test was used to compare distinct category variables, whereas the independent sample *t*-test was used to compare different numerical variables, and a *p*-value of 0.05 was deemed statistically significant.

Results

The study includes 49 patients, 24 (49.0%) from the laser group and 25 (51.0%) from the placebo group. Most of the patients were males with 39 (79.6%) males and 10 (20.4%) females. Table 1 presents the demographic information for the patients. In the baseline data of mean age values and gender distribution, there was no significant difference ($p > 0.05$). There was no statistically significant difference between the two groups of patients who reported severe preoperative discomfort.

Table 2 depicts the mean pain scores of the two groups. The intervention group had lower mean pain scores than the placebo group at all phases of endodontic therapy, with mean pain scores of 72.60 ± 16.97 and 85.00 ± 0.00 during dentin cutting and pulp dropping respectively for the placebo group ($p = 0.01$), while the laser group had significantly lower scores of 43.20 ± 9.85 and 50.40 ± 8.04 for dentin cutting and pulp dropping respectively ($p = 0.02$).

Table 3: Comparison of the two groups' requirement for supplemental anesthesia during dentin cutting

Groups	*No supplemental anesthesia (n, %)*	*Received supplemental anesthesia (n, %)*	*Total (n, %)*	*p-value*
Group under the laser	24 (100)	0 (0)	24 (100)	0.01*
Placebo group	15 (60)	10 (40)	25 (100)	

*p-value is significant

The need for further local anesthetic injections was significantly lesser in the laser group compared to the placebo group ($p = 0.01$). According to the study's findings, 40% of participants in the placebo group required additional anesthesia during dentin cutting owing to pain, compared to 0% in the laser group (Table 3).

The study's inference emphasizes the fact that PBM used in conjunction with anesthesia can be useful in alleviating pain during endodontic treatment.[13]

Discussion

Achieving successful anesthesia procedures for pain-free root canal treatment is one of the important aims of dentistry. Endodontic therapy requires effective anesthesia. One of the most difficult elements of RCT is anesthesia in mandibular molar teeth with irreversible pulpitis. Because of the risks and consequences associated with intraosseous and intraligamentary injections, alternative procedures are required to mitigate these risks.

Photobiomodulation has been considered nowadays as an adjunct to local anesthesia in the management of endodontic pain.[14–17]

Photobiomodulation processes can be studied at the local, regional, and systemic levels. As one of the intracellular processes, increasing mitochondrial metabolic activity leads to increased production of adenosine triphosphate (ATP), nitric oxide (NO), and reactive oxygen species (ROS). A photo-induced ROS stress response has been proposed as an essential component in laser-induced analgesia.[18]

In this study, photobiomodulation therapy was conducted using a diode laser (980 nm).

According to the current study, photobiomodulation therapy (PBMT) during root canal treatment is an effective strategy for increasing the comfort of patients with irreversible pulpitis.

Pain intensity mean scores were lower in the PBMT group than in the placebo group. When the difference in VAS scores between the two groups was evaluated, the PBMT group demonstrated considerably greater pain alleviation than the placebo group.

The results of this study were concurrent with the results of a similar study conducted by Ghabraei et al.[9] who evaluated the effects of PBM in the depth of anesthesia in inferior alveolar nerve block, where their results showed that the mean pain intensity in VAS1 (dentin cutting) in the laser receiving group was lower than in the group that did not receive laser and this difference was statistically significant.

Furthermore, the current study agreed with Tanboga et al.[19] who utilized a low-power laser Er: YAG to prepare 20 tooth cavities on 10 youngsters aged 6–9 years old. Photobiomodulation was administered to half of the patients before beginning endodontic

treatment, while the other half was not. Children were required to rate their discomfort on a VAS from 0 to 5 points, and it was found that children in the laser group experienced less pain. The results of this study demonstrated that the rate of additional injection was substantially lower in patients who underwent laser irradiation before anesthesia than in the placebo group. Although the exact mechanism by which PBM lessens pain is still unknown, numerous studies have shown that it does so by increasing serotonin production, beta-endorphin synthesis, and synaptic acetylcholine esterase activity.[20,21]

The conduction of action potentials was also shown to be slowed down by laser treatments, according to a number of experiments. Additionally, acute pain is induced by the activation of pain receptors that are linked to A-fibers. A-fibers transport noxious stimulus-induced acute and localized pain feelings. The uncomfortable sensation frequently continues long after the damaging stimulus has been removed. C-fibers transmit ongoing painful feelings across the peripheral nervous system. Because C-fibers are extensively branched, pain is felt not only in the injured location but also in nearby regions. Using a rat model, it was discovered that PBM selectively blocked nerve transmission in myelinated A and unmyelinated C-fibers, hence aiding in pain reduction.[22]

This study represents a new approach to minimizing pain during root canal treatment. PBMT should be considered a safe and simple option for decreasing discomfort during this procedure.

The current study was a short-term study with a limited sample size, restricting generalizability. Further research will be conducted to establish the success rate of RCT when PPMT is utilized against a placebo, as well as to predict the duration of the RCT sessions in both groups.

Conclusion

Based on the results of the current study, PBM using diode laser irradiation at 980 nm before anesthesia effectively reduces pain and supplemental injection during RCT. However, the current study was merely a short-term study with a limited sample size, which restricts the results' generalizability. Further research is still required to establish the success rate of RCT when PBM therapy is utilized against a placebo and to predict the time of RCT sessions in both groups.

The use of PBM to reduce pain during endodontic treatment, in conjunction with a local anesthetic, looks to be an intriguing advancement in dentistry. The profession continues to witness technological advancements in order to improve the patient experience while still maintaining a long history of safety in dental pain management.

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Consent for Publication

The author accepts the final version submitted to the journal

Ethical Statement

The Sudan University of Science and Technology's Ethics Committee of Clinical Research (Ref. 2022/3) approved the study protocol. Approval was obtained on 11/03/2022.

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