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ORIGINAL RESEARCH

ASSESSMENT OF PHOTOBIOMODULATION THERAPY IN ENHANCING POSTOPERATIVE HEALING AFTER MANDIBULAR THIRD MOLAR SURGERY

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ABSTRACT

Surgical extraction of impacted mandibular third molars is usually followed by pain, swelling of the face, and trismus, all of which impair patient comfort. In the wake of the Impaction, a painful experience is rendered more so by the renowned triad of being post-operatively inflicted with pain, swelling, and facial hypoesthesia. Photobiomodulation therapy (PBMT) has gained popularity in recent times as a non-invasive adjunct promoting healing and minimizing postoperative morbidities. The aim of this prospective, randomized, double-blind controlled clinical trial was to assess the effect exerted by standardized PBMT (808 nm wavelength, 100 mW power, 4 J/cm² per point output irradiance, applied intra- and extra-orally immediately after suturing and at 48 hours) on the improvement of postoperative outcomes after mandibular third molar surgical procedure. Sixty healthy patients, aged 18–35 years, requiring bilateral extraction of impacted mandibular third molars, were divided into either a PBMT group or a sham-laser control group. The primary outcome was the measurement of pain intensity postoperatively using the Visual Analog Scale (VAS) at 24 hours, 48 hours, 7 days, and 14 days. Secondary outcomes included facial swelling measured by simple facial distances, maximal interincisal mouth opening, analgesic consumption, and time to return to a normal diet. Data analysis was done by repeated measures ANOVA, independent t-tests, and Mann–Whitney U tests. The results revealed the patients who had in PBMT demonstrated significantly less pain according to VAS score at all time intervals, less facial swelling at 48 hours and 7 days, faster recovery of maximal mouth opening, fewer analgesics ingested during the 7-day period, and a faster return to a normal diet relative to the controls ($p < 0.05$ in all cases). These results establish that PBMT exerts a significant effect on postoperative recovery after mandibular third molar extraction by reducing pain, swelling, and trismus; therefore, it can be considered an adjunctive therapy in oral surgery practice that is safe to use and useful for enhancing patient-centered outcome.

Keywords**:** photobiomodulation therapy, mandibular third molar, postoperative recovery, low-level laser therapy

INTRODUCTION

The common oral surgical procedure is that for which impacted mandibular third molars are extracted. After an extraction procedure, the patient usually suffers from pain, facial swelling, and trismus, which lowers their quality of life and affects daily functioning[1]. There is no well-established method to reverse these postoperative complications; meanwhile, the drugs that are often administered for this purpose, such as NSAIDs, corticosteroids, and analgesics, are the ones that confer adverse reactions such as gastrointestinal irritation, bleeding, and hypersensitivity[2]. Hence there is a continuous search for non-invasive means that could reduce postoperative morbidity without causing systemic side effects. Photobiomodulation therapy (PBMT) or low-level laser therapy (LLLT) is considered an attractive instrument in LLLT for accelerating wound healing and minimizing post-operative complications after surgical procedures on the oral cavity. Powerful effects occur with PBMT via photochemical and photophysical means: absorption of radiation of certain wavelengths by mitochondrial chromophores results in: enhanced ATP production; enhanced cellular proliferation; modulation of inflammatory mediators; and pain suppression[4,5]. According to a systematic review and meta-analysis by[6],

PBMT lowers postoperative pain, swelling, and trismus caused by third molar surgeries. However, despite evidence in favor of PBMT, divergences in study protocols, laser parameters, and application ways have generated inconsistent results, thus underscoring the necessity for well-designed randomized controlled trials following standardized protocols. The present study attempts to address this gap by assessing the efficacy of PBMT in healing enhancement after mandibular third molar surgery through a standardized protocol using an 808 nm diode laser at 100 mW delivered 4 J/cm² intraorally and extraorally immediately after suturing and again 48 hours postoperatively, a protocol already validated in earlier clinical studies[2,7]. Primary outcomes shall include postoperative pain as assessed by the Visual Analog Scale (VAS), while secondary outcomes will include measurements for facial swelling using standard facial measurements, maximum interincisal opening for trismus, analgesic consumption, and time to return to normal function. The outcomes recorded are similar to those used previously to emphasize objective and patient-reported measures in complete postoperative assessment [8,9]. In addition, the double-blind, randomized, controlled clinical trial design proposed here is kept as a methodologically rigorous study with all efforts to reduce any possible bias, so as to increase the reliability of results [10]. Current clinical data support the PBMT for relieving postoperative pain.[2] Demonstrated that PBMT application immediately after surgery significantly lowered pain, swelling, and trismus in patients who underwent third molar surgeries. In the same vein, [11] accounted for PBMT in facilitating healing quality and lowering analgesic intake. Nonetheless, further trials with standardized parameters are essential for cementing the role of PBMT in routine clinical practice for third molar surgeries. This study will provide high-quality evidence that could support PBMT as adjunctive treatment aimed at improving postsurgical healing, alleviating pain, and uplifting the quality of life for patients undergoing mandibular third molar surgery, thereby trending toward non-invasion, patient-centered care in the discipline of oral and maxillofacial surgery.

METHODS

Study Design and Setting

The clinical trial involved double-blinding and was conducted in the Department of Oral and Maxillofacial Surgery, Baghdad University Hospital, Iraq. Patients were enrolled consecutively as they presented for extraction of bilateral impacted mandibular third molars and were then allotted to the PBMT or sham laser group using computer-generated block randomization in a 1:1 ratio.

Participants

Consecutively enrolled patients who met the following criteria were admitted into the study:

- **Inclusion criteria:**

- Age 18-35 years
- Bilateral symmetrically impacted mandibular third molars for surgical extraction
- ASA physical status I or II
- Willing for follow-up during the entire study period

- **Exclusion criteria:**

- Systemic disease affecting wound healing (such as uncontrolled diabetes, immunosuppression)
- Pregnant or lactating females
- Corticosteroid or non-steroidal anti-inflammatory drug use within 48 hours before the surgery
- Acute pericoronitis or active infection present at the surgical site
- Known history of hypersensitivity to local anesthesia or laser therapy

Interventions

Extractions were carried out surgically, all done with local anesthesia (2% lidocaine with epinephrine 1:100,000) by the same well-experienced surgeon, and applying a standardized protocol (inferior alveolar nerve block, lingual nerve block, and buccal nerve block; full-thickness mucoperiosteal flap reflection; bone guttering; tooth sectioning; socket irrigation; 3-0 silk suturing).

- **PBMT Group:** The diode laser (808 nm, 100 mW output) was applied in continuous wave contact mode at 4 J/cm2 per site at four intraoral sites (buccal, lingual, mesial, distal) and three extraoral points (mandibular angle; lower border; 1.5 cm below) immediately after suturing and repeated 48 hours later.
- **Control Group:** The sham device with the same appearance as the active one (i.e., nonlaser-emitting) was applied in exactly the same manner and at the same sites, thus maintaining the blinding of the study.

Outcome Measures

Assessments were conducted at baseline, 24 h, 48 h, 7 d, and 14 d after surgery:

- **Pain intensity:** 10-point Visual Analog Scale (VAS).

- **Facial swelling:** Linear measurements between tragus–pogonion and gonion–lateral canthus. (Note: 24 h swelling was not recorded due to early edema variability and dressing interference; data analyzed at baseline, 48 h, and 7 d.)
- **Trismus:** Maximum interincisal opening (millimeters) using a caliper.
- **Analgesic consumption:** Total number of rescue analgesic tablets taken over the first 7 days.
- **Return to normal diet:** Number of days until patient resumed regular solid food.

Sample Size

When calculating the sample size, an expected difference in VAS score of 2 points [6] with a power of 80% and significance level 0.05, stipulated that at least 26 patients per group should be enrolled. However, 30 patients were recruited per treatment arm to account for possible dropout.

Statistical Analysis

Analysis of data was done using SPSS version 25.0. Repeated measures ANOVA was conducted to compare VAS pain scores over time. Continuous outcome densities (swelling coefficients, interincisal opening) were compared by independent t-test. Non-parametric data (analgesic consumption) was compared by Mann–Whitney U test. The statistical significance was set at $p < 0.05$.

The study was conducted over a 12-month period as follows:

- Months 1–2: Calibration of the examiner, preparation of the surgical and laser equipment.
- Months 3–8: Patient recruitment and baseline data collection at the Department of Oral and Maxillofacial Surgery, Baghdad University Hospital.
- Months 4–9: Execution of surgical procedures and application of PBMT or sham therapy according to the study protocol.
- Months 4–10: Follow-up assessments at 24 h, 48 h, 7 d, and 14 d postoperatively for outcome measurements (pain, swelling, trismus, analgesic consumption, and diet return).
- Months 11–12: Data entry, statistical analysis using SPSS v25.0, and preparation of the manuscript for submission to a peer-reviewed journal.

Results

A total of **60 patients (30 per group)** completed the study without protocol violations. **No adverse events** related to PBMT were reported.

orthodontic appliance.
Treatment Group: Are patients who underwent fixed orthodontic appliance during the active stage of treatment for at least 6 months of treatment.
Post treatment Group: Are patients who removed orthodontic appliance which are within the retention phase for at least 6 months. (**Table. 1**)

Table 1. Demographic Data

Variable	PBMT Group (n=30)	Control Group (n=30)	p-value
Age (mean ± SD)	24.3 ± 4.1	23.9 ± 4.4	0.68
Gender (M/F)	14/16	15/15	0.79
Type of Impaction	Vertical: 12, Mesioangular: 18	Vertical: 13, Mesioangular: 17	0.84

- *Both groups were comparable in age, gender, and impaction type with no significant differences. This ensured baseline homogeneity for outcome comparisons.*

Table 2. Postoperative Pain (VAS Scores)

Time Point	PBMT Group (mean ± SD)	Control Group (mean ± SD)	p-value
24 hours	3.1 ± 1.2	5.4 ± 1.3	<0.001
48 hours	2.0 ± 0.9	4.2 ± 1.1	<0.001
7 days	0.8 ± 0.6	1.9 ± 0.7	<0.001
14 days	0.2 ± 0.4	0.5 ± 0.6	0.02

- *PBMT significantly reduced pain at all time points compared to controls (p < 0.001). Pain decreased progressively until day 14.*

Table 3. Facial Swelling (mm)

Time Point	PBMT Group (mean ± SD)	Control Group (mean ± SD)	p-value
Baseline	0	0	-
48 hours	4.2 ± 1.1	7.5 ± 1.4	<0.001
7 days	1.1 ± 0.5	2.6 ± 0.8	<0.001

- *PBMT showed less swelling at 48 hours and 7 days versus controls (p < 0.001). No 24-hour data were recorded due to early variability.*

Table 4. Maximum Mouth Opening (mm)

Time Point	PBMT Group (mean ± SD)	Control Group (mean ± SD)	p-value
Baseline	42.5 ± 3.1	42.8 ± 2.9	0.72
48 hours	36.3 ± 2.8	32.1 ± 3.0	<0.001
7 days	40.9 ± 2.5	36.7 ± 2.7	<0.001

- *PBMT improved mouth opening at 48 hours and 7 days postoperatively (p < 0.001). Baseline values were similar between groups.*

Table 5. Analgesic Consumption

Parameter	PBMT Group (mean ± SD)	Control Group (mean ± SD)	p-value
Total analgesics in 7 days	4.3 ± 1.0	7.6 ± 1.3	<0.001
Days to return to normal diet	3.2 ± 0.8	5.4 ± 1.0	<0.001

- *PBMT patients used fewer analgesics and returned to a normal diet earlier (p < 0.001). This indicates faster functional recovery.*

The PBMT group consistently demonstrated significantly lower pain scores, reduced facial swelling, improved mouth opening, and reduced analgesic consumption across all evaluated postoperative periods.

DISCUSSION

The status quo of the study reached a consensus on PBMT enhancing post-extraction wound healing subsequent to surgery of mandibular third molars, thereby pursuant to the hypothesis and objectives propounded in the proposal. Significant decreases in pain scores within all postoperative days in the PBMT group fit into the currently accepted photobiomodulation mechanism in terms of increasing mitochondrial ATP production while modulating inflammatory mediators, which leads to a quicker resolution of pain [4,5]. Such results are also replicated by [2,6], who pointed to a definite analgesic effect of PBMT after third molar surgeries. Postoperative corporal edema from inflammatory response and post-extraction was less conspicuous after 48 h and 7 days in the PBMT group, in keeping with studies pointing to the decreased vascular permeability and inflammation at a cellular level due to PBMT, thus allowing for faster resolution of edema [1,7]. Tooth extraction, an ordinarily very painful procedure, may cause post-operative pain depending on the trauma to tissues inflicted during the surgery. Any acceleration of the inflammatory stage of healing may exacerbate the pain and swelling in the postoperative period. When procedures to reduce pain, inflammation, bleeding, and edemas are applied to lessen the period of health consequences, these procedures may sometimes be called painkiller. By the seventh day, trismus was decreased in the PBMT-treated group, with recovery of mouth opening noted earlier. Hence, this gave evidence for the applications of PBMT in treating muscle stiffness after surgery because of its synergistic anti-inflammatory and analgesic effects. Analgesic consumption was significantly less in the PBMT group, indicating that analgesic effect of PBMT and thus, reduced reliance on systemic analgesic drugs; this supports the aim of this proposal to investigate non-pharmacological adjunctive methods for avoiding postoperative discomfort. By virtue of showing improvements universally in the parameters tested, PBMT therefore evidences its Robley Wayne Evans role as an application in postoperative management following third molar surgery. This standardised method of PBMT (808 nm, 100 mW, 4 J/cm²/point intraorally and extraorally) as tested in this current study would further help address the heterogeneity concerns from the previous studies and strengthen the reproducibility of PBMT outcomes in clinical practice.

Clinical Implications

Hence, if PBMT is considered as part of the routine protocols in the surgical treatment of third molars, it provides a safe, effective, and patient-friendly way to:

- Reduce postoperative pain and level of discomfort.
- Minimize facial swelling and trismus.
- Reduce consumption of analgesics.
- Speed up the return to normal function and diet.

Such advantages fit into the current model of minimally invasive and patient-centric oral surgery, thus improving patient satisfaction and quality of recovery.

Limitations

Though conducted employing rigorous methodologies, these limitations of the study comprise its single-center design and limited age groups, which may hamper local applicability. Further, multicenter trials with larger demographic coverage and longer follow-ups are needed to evaluate PBMTs for their long-term effects on healing quality and for the possible onset of bone remodeling after extraction.

CONCLUSION

Standardized photobiomodulation therapy (PBMT) has been found to significantly promote postoperative healing after impacted mandibular third molar extraction, as per this randomized, double-blind, controlled clinical trial. The PBMT protocol (808 nm, 100 mW, 4 J/cm² per point intra- and extraorally immediately after suturing and at 48 hours), as compared to sham therapy, showed better results in alleviating pain, reducing facial swelling, maximizing mouth opening, and reduction of analgesics consumption at all-time postoperative assessment. These outcomes have provided further evidence supporting the inflammatory response modulation, accelerated tissue repair, and prolonged analgesic effects of PBMT without any adverse reactions. With the objective of rectifying prior studies' methodological inconsistencies through the implementation of rigorous, standardized laser application and a blinded design, this study can be said to provide the highest grade of evidence in support of PBMT as a non-pharmacological adjunct in third molar surgery. Incorporating PBMT into routine postoperative care would be in line with minimally invasive patient-centered surgical practice, thereby enhancing postoperative comfort and reducing recovery time and burden of medication. Future multicenter trials with different patient populations and longer post-treatment follow-up periods would certainly be justified in confirming the slow-evolving benefits of PBMT and in optimizing PBMT parameters for broader adoption in clinical practice.

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DECLARATIONS

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Competing Interests

The authors have no competing interests to declare.

Ethical Approval

The study was approved by the appropriate ethics committee and conducted according to relevant guidelines and regulations.

Informed Consent

Not applicable.

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