

The role of low-level laser therapy in the postoperative management of dental extractions: evidence, protocols and perspectives

O papel do laser de baixa potência no pós-operatório de exodontias: evidências, protocolos e perspectivas

João Victor Monteiro Moura¹, Júlio César Monteiro Moura¹, Fernando Monteiro Reginato¹,
Kyelcyara Mychaella Batista Cavalcanti², Jonas Richardson Almeida Ramos², Kemmily
Idalina da Silva Souza², Laudenice de Lucena Pereira³, Matheus Leite Bezerra⁴, Cíntia Régia
Fonseca Ivo de Andrade⁴, João Vitor Alves Pereira⁴, Igor Figueiredo Pereira¹

ABSTRACT

Dental extraction is one of the most frequently performed surgical procedures in oral and maxillofacial surgery, often associated with postoperative pain, facial edema, trismus, and alveolar osteitis. Photobiomodulation (PBM), formerly known as low-level laser therapy (LLLT), is a non-invasive modality that acts through photochemical mechanisms primarily via activation of cytochrome c oxidase (CCO) without deleterious thermal effects, promoting anti-inflammatory, analgesic, and biostimulatory responses. This integrative review aimed to critically analyze the evidence on the efficacy and dosimetric protocols of PBM/LLLT in the postoperative management of dental extractions. Searches were conducted in

¹Centro Universitário Maurício de Nassau – João Pessoa – Paraíba – Brasil. ORCID: <https://orcid.org/0009-0008-0878-2699>

¹Centro Universitário Maurício de Nassau – João Pessoa – Paraíba – Brasil. ORCID: <https://orcid.org/0000-0003-1805-4683>

¹Centro Universitário Maurício de Nassau – João Pessoa – Paraíba – Brasil. ORCID: <https://orcid.org/0009-0003-3495-7417>

¹Centro Universitário Maurício de Nassau – João Pessoa – Paraíba – Brasil. ORCID: <https://orcid.org/0009-0006-0676-5241>

²Centro Universitário Unipê– João Pessoa – Paraíba – Brasil. ORCID: <https://orcid.org/0009-0003-9820-7957>

²Centro Universitário Unipê– João Pessoa – Paraíba – Brasil. ORCID: <https://orcid.org/0009-0004-2436-4033>

²Centro Universitário Unipê– João Pessoa – Paraíba – Brasil. ORCID: <https://orcid.org/0009-0003-2203-2660>

³Universidade Federal da Paraíba – João Pessoa – Paraíba – Brasil. ORCID: <https://orcid.org/0000-0002-6539-9716>

⁴Centro Universitário Unifip– Patos – Paraíba – Brasil. ORCID: <https://orcid.org/0009-0000-7326-7732>

⁴Centro Universitário Unifip– Patos – Paraíba – Brasil. ORCID: <https://orcid.org/0009-0006-8568-5775>

⁴Centro Universitário Unifip– Patos – Paraíba – Brasil. ORCID: <https://orcid.org/0009-0002-4466-7870>

PubMed/MEDLINE, Scopus, Web of Science, BVS/LILACS, and the Cochrane Library, covering publications from 2020 to 2026. Fourteen studies met the eligibility criteria, including randomized clinical trials (RCTs), systematic reviews, and meta-analyses. PBM demonstrated statistically significant reductions in postoperative pain (SMD: 1.09; 95% CI: 1.63 to 0.55; $P<0.001$), facial edema (SMD: 0.50; 95% CI: 0.88 to 0.11; $P=0.01$), and trismus (SMD: 0.35; 95% CI: 0.16 to 0.53; $P=0.002$). For alveolar osteitis, PBM showed equivalence or superiority to Alveogyl dressing. Wavelengths between 630 and 1000 nm and energy densities of 2 to 8 J/cm² were the most frequently reported. Pre-emptive protocols demonstrated promising preliminary results. PBM constitutes a safe and effective adjuvant resource in the postoperative management of dental extractions; the absence of standardized dosimetric protocols remains the main limitation of the field.

Keywords: photobiomodulation; low-level laser therapy; tooth extraction; postoperative pain; wound healing.

RESUMO

A exodontia está entre os procedimentos cirúrgicos mais realizados na cirurgia bucomaxilofacial, frequentemente associada a dor pós-operatória, edema facial, trismo e osteíte alveolar. A fotobiomodulação (FBM), anteriormente designada laserterapia de baixa potência (LBP), é uma modalidade não invasiva que atua por mecanismos fotoquímicos principalmente via ativação da citocromo c oxidase (CCO) sem efeitos térmicos deletérios, promovendo respostas anti-inflamatórias, analgésicas e bioestimulatórias. Esta revisão integrativa objetivou analisar criticamente as evidências sobre a eficácia e os protocolos dosimétricos da FBM/LBP no pós-operatório de exodontias. Buscas foram conduzidas em PubMed/MEDLINE, Scopus, Web of Science, BVS/LILACS e Cochrane Library, abrangendo publicações de 2020 a 2026. Quatorze estudos atenderam aos critérios de elegibilidade, incluindo ensaios clínicos randomizados (ECRs), revisões sistemáticas e meta-análises. A FBM demonstrou reduções estatisticamente significativas na dor pós-operatória (DMP: 1,09; IC 95%: 1,63 a 0,55; $P<0,001$), no edema facial (DMP: 0,50; IC 95%: 0,88 a 0,11; $P=0,01$) e no trismo (DMP: 0,35; IC 95%: 0,16 a 0,53; $P=0,002$). Para a osteíte alveolar, a FBM mostrou equivalência ou superioridade ao curativo com Alveogyl. Os comprimentos de onda entre 630 e 1000 nm e densidades de energia de 2 a 8 J/cm² foram os mais relatados. Protocolos pré-emptivos demonstraram resultados preliminares promissores. A FBM constitui recurso

adjuvante seguro e eficaz no pós-operatório de exodontias; a ausência de protocolos dosimétricos padronizados permanece a principal limitação do campo.

Palavras-chave: fotobiomodulação; laserterapia de baixa potência; extração dentária; dor pós-operatória; cicatrização de feridas.

1 INTRODUCTION

Dental extraction is one of the most frequently performed surgical procedures in general dentistry and oral and maxillofacial surgery, often associated with postoperative complications such as acute pain, facial edema, trismus, and alveolar osteitis in a significant proportion of patients (1). Alveolar osteitis commonly known as dry socket represents the most prevalent post-extraction complication, with an incidence ranging from 1% to 37% in cases involving impacted mandibular third molars (1,7).

Conventional postoperative management relies on NSAIDs, corticosteroids, analgesics, and alveolar dressings. These pharmacological approaches carry systemic adverse effects, risks of drug interactions, and growing concerns regarding antimicrobial resistance, in addition to restrictions on their use in special populations (5).

PBM formerly designated LLLT has emerged as a non-invasive, non-pharmacological therapeutic alternative. PBM employs light in the visible red spectrum (620–700 nm) and near-infrared range (700–1100 nm) at power densities sufficient to trigger photobiological cascades without causing thermal tissue damage (9,10). The primary mechanism involves photon absorption by CCO, complex IV of the mitochondrial respiratory chain, promoting nitric oxide dissociation, increased ATP synthesis, and modulation of reactive oxygen species (ROS), with positive regulation of anti-inflammatory cytokines and growth factors (9). These events culminate in fibroblast proliferation, angiogenesis, collagen synthesis, and accelerated epithelialization processes directly relevant to alveolar repair.

Despite growing evidence, substantial methodological heterogeneity persists regarding application parameters: wavelength, energy density, output power, number of sessions, and timing of application (1,2). This review aimed to synthesize and critically analyze the evidence on the role of PBM/LLLT in the postoperative management of dental extractions, focusing on clinical outcomes and dosimetric parameters employed.

2 MATERIAL AND METHODS

Study type

This is an integrative literature review, a method that allows the synthesis of studies with different methodological approaches, conducted in accordance with PRISMA guidelines.

Research question

The research question was: "In patients undergoing dental extractions, what is the efficacy of PBM/LLLT in the control of postoperative pain, edema, trismus, and alveolar wound healing?"

Search strategy and eligibility criteria

Searches were conducted in PubMed/MEDLINE, Scopus, Web of Science, BVS/LILACS, and the Cochrane Library, covering publications from January 2020 to June 2026, using the following strategy: ("low-level laser therapy" OR "photobiomodulation" OR "LLLT") AND ("tooth extraction" OR "dental extraction" OR "third molar surgery") AND ("postoperative pain" OR "edema" OR "trismus" OR "wound healing" OR "alveolar osteitis"). RCTs, systematic reviews, meta-analyses, and integrative reviews were included, in English, Portuguese, and Spanish, with measurable clinical outcomes and description of PBM parameters. Case reports, opinion articles, studies without dosimetric data, and duplicate publications were excluded.

Study selection and data extraction

Screening was performed by titles and abstracts, followed by full-text reading of eligible articles, with disagreements resolved by consensus. Data were extracted using a standardized form containing: study design, sample size, type of extraction, PBM parameters (wavelength, output power, energy density, number of sessions, application points), and clinical outcomes.

3 RESULTS

Study selection

Database searches returned 312 references. After removal of duplicates and exclusion by title and abstract, articles were read in full and 14 fully met the eligibility criteria and were

included in this review. Figure 1 presents the article search steps and Table 1 presents the characteristics of all included studies.

Figure 1. Article search flowchart.

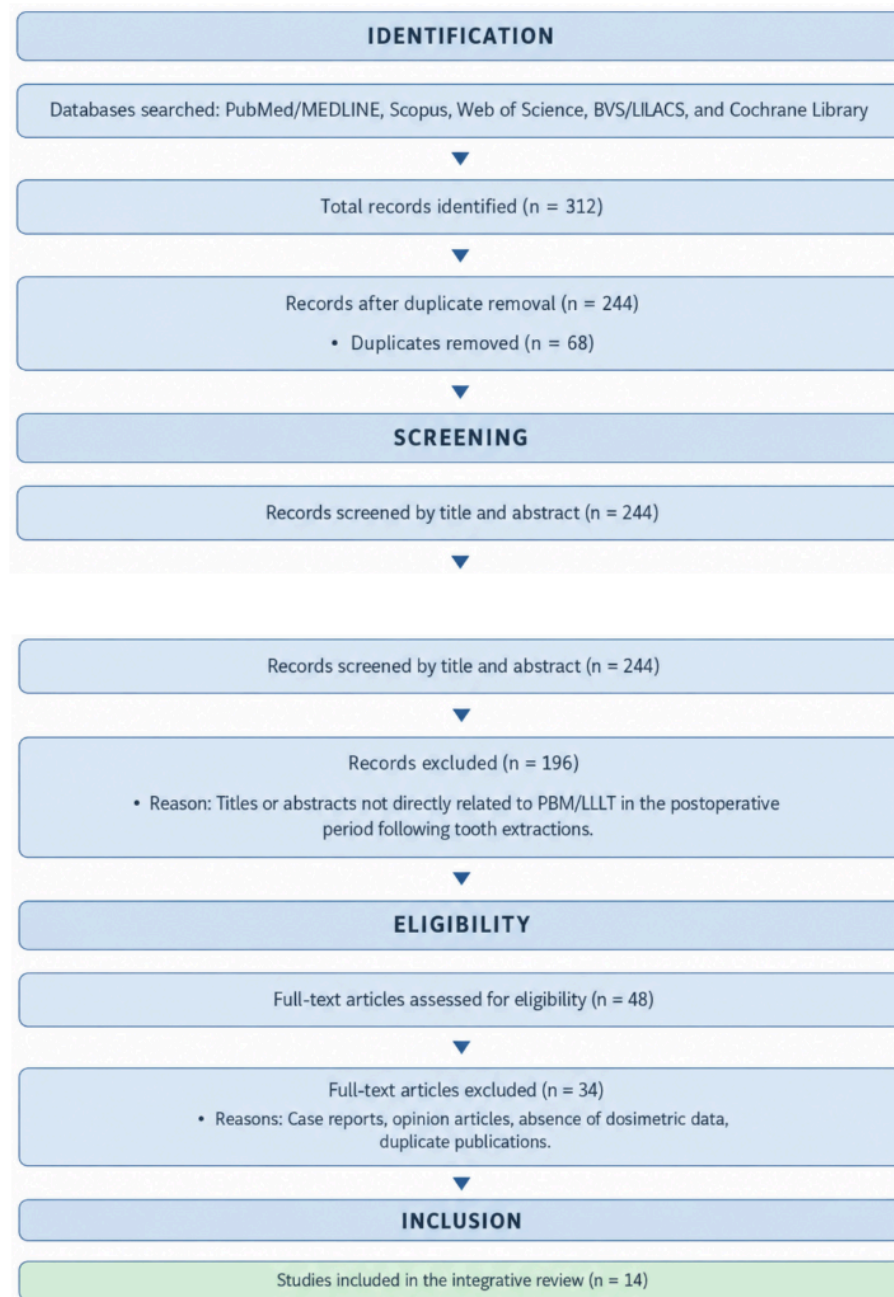


Table 1. Characteristics of studies included in the integrative review.

Author/Year	Study design	n	Wavelength (nm)	Dose (J/cm ²)	Sessions	Outcomes
Lacerda-Santos et al. (1) 2023	SR/MA	RCTs (var.)	630–980	1–8	1–5	Pain, edema, trismus
Camolesi et al. (2) 2024	SR/MA	RCTs (var.)	660–1000	3–7	2–4	Pain, edema, trismus, QoL
Cetira Filho et al. (3) 2022	Split-mouth RCT	62	660 + 808	4–6	3	Pain, edema, OxStress, QoL
ALHarthi et al. (4) 2023	RCT	60	940	4	5	Alveolar osteitis (VAS)
Salaberry et al. (5) 2024	RCT protocol	38	660 (intra) + 850 (extra)	12/108	3	Edema, pain, trismus
Othman et al. (6) 2024	RCT	20	650 and 810	≈4	3	Bone density, TM
Shafaei et al. (7) 2020	SR/MA	7 RCTs	630–980	2–8	2–5	Pain, alveolar osteitis
Gopal et al. (8) 2024	SR	14 studies	660–1064	2–8	1–6	Epithelialization, pain
Hamblin (9) 2022	Review	-	-	-	-	PBM mechanisms (CCO)
Ayed et al. (10) 2025	Review	-	-	-	-	PBM dental applications
Sourvanos et al. (13) 2023	Scoping review	RCTs (var.)	630–980	2–10	1–5	Pain, wound healing
Daly et al. (14) 2022	Cochrane SR	RCTs (var.)	Variable	Variable	Variable	Alveolar osteitis management
Uzeda et al. (15) 2025	RCT	40	808	4	3	Pain, edema, trismus
WALT (12) 2022	Guideline	-	Variable	Variable	-	Dosimetric parameters

SR: systematic review; MA: meta-analysis; RCT: randomized clinical trial; QoL: quality of life; n: sample size; var.: variable; OxStress: oxidative stress; VAS: Visual Analogue Scale; TM: tissue morphology; intra: intraoral; extra: extraoral; CCO: cytochrome c oxidase.

Efficacy of PBM in controlling postoperative pain

Postoperative pain, assessed predominantly by the Visual Analogue Scale (VAS), was the most frequently investigated outcome. The meta-analysis by Lacerda-Santos et al. (1) demonstrated a statistically significant reduction in pain in the PBM group on the third postoperative day (SMD: 1.09; 95% CI: 1.63 to 0.55; $P < 0.001$), with the effect maintained until the seventh day (SMD: 1.11; 95% CI: 1.63 to 0.58; $P < 0.001$). The split-mouth RCT by Cetira Filho et al. (3), conducted in 62 patients undergoing third molar surgery, showed significantly lower pain scores in the LLLT group at 4 hours ($p = 0.009$) and 6 hours ($p = 0.048$),

with LLLT alone demonstrating non-inferiority relative to the nimesulide-LLLT combination. The systematic review by Gopal et al. (8), covering 14 studies, confirmed significant differences between PBM and control groups for pain and wound epithelialization, with reduced analgesic consumption and no adverse effects.

Efficacy of PBM in controlling facial edema and trismus

The meta-analysis by Lacerda-Santos et al. (1) demonstrated a significant reduction in edema at 48 postoperative hours (SMD: 0.50; 95% CI: 0.88 to 0.11; $P=0.01$), corroborated by Camolesi et al. (2), who reported significantly smaller facial measurements on days 2 and 7 after surgery. Cetira Filho et al. (3) additionally identified a significantly shorter mandibular angle–lateral orbital canthus distance on day 7 in the LLLT group ($p=0.037$), supporting the role of pre-emptive PBM in attenuating inflammatory peaks prior to tissue trauma.

For trismus, Lacerda-Santos et al. (1) demonstrated a significant improvement in mouth opening on the seventh postoperative day (SMD: 0.35; 95% CI: 0.16 to 0.53; $P=0.002$), a result consistent with the findings of Camolesi et al. (2). The ongoing RCT by Salaberry et al. (5), comparing pre-emptive PBM (660 nm intraoral + 850 nm LED extraoral) versus preoperative corticosteroid, includes edema and trismus among its primary and secondary outcomes; results are pending publication (5).

PBM in the management of alveolar osteitis

Shafae et al. (7) pooled data from 7 RCTs and demonstrated the superiority of PBM over conventional mechanical debridement in reducing pain associated with alveolar osteitis. The RCT by ALHarthi et al. (4) randomized 60 patients into four groups: mechanical curettage (MC), MC + Alveogyl, MC + PBM (940 nm), and MC + Alveogyl + PBM. The Alveogyl and PBM groups showed a significant reduction in pain compared to MC alone ($P<0.01$), with PBM demonstrating equivalence to Alveogyl as a therapeutic adjunct. The Cochrane review by Daly et al. (14) positioned PBM as one of the most promising local interventions for alveolar osteitis management, highlighting the need for larger and better-controlled trials (14).

Dosimetric parameters

Dosimetric analysis revealed wide variation across studies. Table 2 summarizes the identified ranges.

Table 2. Summary of PBM dosimetric parameters reported in the included studies.

Parameter	Minimum	Maximum	Most frequent	Unit
Wavelength	630	1064	660 / 808	nm
Output power	30	200	100	mW
Energy density	1	10	4–6	J/cm ²
No. of sessions	1	6	3	sessions
Time per point	10	60	30	seconds

Values represent ranges identified across included studies, not data from specific individual studies.

Wavelengths of 660 nm and 808–980 nm were the most frequently employed. Othman et al. (6) demonstrated that the 810 nm wavelength was superior for bone density outcomes as assessed by radiographic evaluation, while 650 nm showed better performance in histological soft tissue healing parameters, indicating that wavelength selection should be guided by the target tissue. WALT guidelines (12) recommend minimum parameter reporting in all laser therapy publications; however, adherence in the reviewed literature was inconsistent.

4 DISCUSSION

The body of evidence from 2020–2026 consistently supports PBM as an effective adjuvant in the management of postoperative pain, edema, and trismus following dental extractions. The convergence of results between the meta-analyses of Lacerda-Santos et al. (1) and Camolesi et al. (2) strengthens confidence in these findings, reflecting improvements in methodological rigor particularly in randomization, blinding, and dosimetric reporting compared to earlier inconclusive reviews.

The split-mouth RCT by Cetira Filho et al. (3) offers an especially informative contribution: the non-inferiority of LLLT alone relative to the nimesulide-LLLT combination suggests that PBM as monotherapy can achieve analgesic results comparable to pharmacological adjuvants. This is particularly relevant for populations with contraindications to NSAIDs or corticosteroids including diabetic patients, those on anticoagulants, and individuals with hepatic disease for whom a non-pharmacological alternative represents a clinically significant option.

The wavelength comparison by Othman et al. (6) establishes an important clinical principle: wavelength selection should be tissue-specific. Red light (650 nm) acts preferentially on superficial soft tissues, while near-infrared (808–980 nm) penetrates more deeply, reaching bone tissue in formation. Simple extractions may benefit from protocols in the red spectrum, while third molar surgeries with extensive bone involvement may require near-infrared wavelengths.

For alveolar osteitis, the combined evidence from ALHarthi et al. (4), Shafae et al. (7), and Daly et al. (14) positions PBM as a viable and evidence-based alternative or complement to eugenol-based dressing. PBM additionally offers the absence of cytotoxic effects, eliminates the need for dressing changes, and simultaneously biostimulates alveolar repair.

The pre-emptive approach of Salaberry et al. (5) explores a conceptually relevant question: whether modulation of the tissue inflammatory state prior to surgical trauma can attenuate the magnitude of postoperative sequelae. If confirmed, this strategy could reduce or replace the preoperative use of corticosteroids in selected patients.

The main limitation identified across all included studies is the absence of standardized dosimetric protocols. The wide variation in wavelength, energy density, output power, number of sessions, and application points hampers direct comparison and clinical translation. WALT recommendations (12) represent a necessary first step, but their adoption in the published literature remains inconsistent. Future multicenter RCTs with rigorous parameter reporting and objective secondary outcomes including inflammatory biomarkers such as IL-6 and TNF- α are essential for advancing the field.

5 CONCLUSION

Photobiomodulation/low-level laser therapy constitutes an adjuvant therapeutic resource with demonstrated efficacy in controlling postoperative pain, facial edema, and trismus following dental extractions, and shows equivalence or superiority to conventional dressing in the management of alveolar osteitis. Its biological effects are grounded in well-established photochemical mechanisms, particularly mitochondrial photobiomodulation via cytochrome c oxidase. The absence of standardized dosimetric protocols remains the main obstacle to the consolidation of PBM in evidence-based clinical practice. PBM represents a safe non-pharmacological option with the potential to reduce postoperative analgesic and anti-inflammatory consumption, particularly relevant for special populations. Multicenter

randomized clinical trials with rigorous dosimetric standardization constitute the primary research priority for the field.

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