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Literature Review

Photobiomodulation in the Management of Inferior Alveolar Nerve Paresthesia/Dysesthesia following Maxillofacial Surgical Treatments: A Review of the Literature (2020–2026)

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Abstract

Objective: To synthesize updated scientific evidence (2020–2026) on the efficacy of photobiomodulation (PBM) —low-level laser therapy (LLLT)— in neurosensory recovery of patients with inferior alveolar nerve (IAN) paresthesia or dysesthesia following maxillofacial surgical procedures.

Data sources: PubMed/MEDLINE, Cochrane Library, Scopus, Web of Science, Embase. MeSH terms: 'photobiomodulation', 'low-level laser therapy', 'inferior alveolar nerve', 'paresthesia', 'third molar', 'neurosensory'. Period: January 2020 – January 2026.

Selection: Randomized clinical trials (RCTs), case series with ≥4 patients, and systematic reviews published in English or Spanish, with quantified evaluation of neurosensory recovery using VAS and/or objective neurosensory tests.

Results: Nine studies were included: 2 systematic reviews (one with meta-analysis), 4 RCTs, and 3 case series/observational studies. The 808–810 nm wavelength (GaAlAs diode, near-infrared) was most frequently applied, with powers of 100–200 mW, fluence of 10 J/cm² per point, and 10–12 sessions. The meta-analysis by Ma et al. (2023, n=14 studies) demonstrated significant overall improvement in IAN neurosensory recovery with PBM ($p<0.05$). The triple-blind RCT by Yari et al. (2024) showed sustained benefit at 9 months in chronic NSD (>6 months). Early treatment initiation (<6 months) and younger patient age are favorable prognostic factors.

Conclusion: PBM with 808–810 nm diode laser is a noninvasive, safe modality with growing evidence for IAN neurosensory recovery across multiple maxillofacial surgical etiologies, including third molar extraction, sagittal split osteotomy (BSSO), implant placement, and traumatic mandibular fracture. Protocol heterogeneity limits high-certainty guideline formulation. Multicenter RCTs with standardized parameters, outcomes, and etiology-specific subgroups are needed.

Keywords: *Photobiomodulation; Low-Level Laser Therapy; Inferior Alveolar Nerve; Paresthesia; Dysesthesia; Mandibular Third Molar; Tooth Extraction; Sagittal Split Osteotomy; Orthognathic Surgery; Dental Implants; Mandibular Fracture; Neurosensory Recovery; Oral and Maxillofacial Surgery.*

1. Introduction

The inferior alveolar nerve (IAN) —a sensory branch of the mandibular nerve (V3)— runs through the inferior dental canal and represents the nerve structure most frequently injured in the context of surgical procedures of the maxillofacial region. Postoperative neurosensory disturbances constitute one of the most relevant and feared complications in this specialty, both for their impact on patient quality of life and for their medicolegal implications [1,2].

In oral surgery, surgical extraction of impacted mandibular third molars carries the highest incidence of IAN neurosensory deficit (NSD). Its close anatomical relationship with the inferior dental canal explains why transient NSD occurs in 0.26–8.4% of cases and permanent NSD —persisting beyond 6 months— in 0.1–2% [2]. The most consistently associated risk factors include horizontal or distoangular position, deep impaction (Pell-Gregory class III), advanced patient age, prolonged surgical time, number of fractured roots, and close topographic relationship between the apex and the dental canal [3,7].

In orthognathic surgery, the bilateral sagittal split osteotomy (BSSO) is the leading iatrogenic cause of IAN injury in adult patients. The incidence of transient NSD ranges from 10% to 85% across series, with permanent deficit rates of 0.3% to 1.4%, depending on the technique used, operator experience, and degree of mandibular displacement. Stretching, contusion, or partial sectioning of the nerve during osteotomy or proximal segment positioning are the most frequently implicated mechanisms [11,12].

Dental implant placement in the posterior mandible represents another relevant cause of IAN injury. Post-implant neurosensory disturbances can affect up to 40% of patients in the first weeks, although most correspond to transient deficits due to neuropraxia. Direct IAN injury during implant osteotomy, pressure exerted by the implant on the canal, or heat transfer during drilling are the most commonly described mechanisms in the literature [12,16].

Mandibular trauma and surgical treatment of angle, body, or symphysis fractures, together with oncological resection and mandibular reconstruction procedures, constitute additional causes of IAN NSD [18]. In any of these etiologies, the deficit may present as paresthesia (altered sensation without stimulus), hypoesthesia (reduced sensitivity), anesthesia (total loss of sensitivity), dysesthesia (abnormal sensation upon stimulus, frequently unpleasant), or allodynia (pain in response to normally non-painful stimuli). According to the Sunderland classification, injuries are graded from grade I (neuropraxia, reversible focal demyelination) to grade V (neurotmesis, complete section of the axon and epineurium) [4]. The prognosis for spontaneous recovery is inversely proportional to the injury grade.

Conventional management of NSD includes watchful waiting (given that most injuries are neuropraxias that resolve spontaneously within days to weeks), complex vitamin B (B1, B6, B12), corticosteroids in the acute phase (first 72 hours), anticonvulsants for the neuropathic component (gabapentin, carbamazepine), and, in selected cases of confirmed neurotmesis, microsurgery (neurolysis, direct epineural suture, or nerve grafting). However, the efficacy of these modalities in chronic NSD (>6 months) is limited and without consensus in the literature [2].

In this context, photobiomodulation (PBM), formerly known as low-level laser therapy (LLLT), has emerged as a non-invasive, painless, and adverse-effect-free therapeutic alternative for stimulating peripheral nerve regeneration, with broad applicability across all the aforementioned etiologies [6,9].

PBM promotes regeneration through modulation of cellular and molecular processes involved in tissue repair. Its primary chromophore is cytochrome c oxidase (CCO), an enzyme that absorbs light energy in the red and near-infrared spectrum (630–1000 nm) [6]. This interaction increases ATP production, stabilizes mitochondrial membrane potential, and activates intracellular signaling pathways, promoting a favorable environment for neuronal survival and regeneration. Simultaneously, it induces a controlled release of reactive oxygen species (ROS) with cell signaling function, and increases the availability of nitric oxide (NO), contributing to improved perfusion and oxygenation of injured tissues. In the peripheral nervous system, these effects translate into greater proliferation and differentiation of Schwann cells—essential for axonal remyelination—and increased expression of neurotrophic factors such as nerve growth factor (NGF) and brain-derived neurotrophic factor (BDNF), fundamental for neuronal survival and axonal growth during the repair process [8,10].

From a clinical standpoint, PBM efficacy also depends on the ability of radiation to reach the target tissue. Wavelengths between 808 and 830 nm achieve the greatest penetration in soft and bone tissues, enabling more effective irradiation of the IAN pathway. This characteristic explains why this wavelength range is the most widely used in clinical trials and concentrates the largest portion of available evidence on neurosensory recovery [10,11].

The objective of this review is to synthesize and critically analyze the available scientific evidence (2020–2026) on the efficacy, application parameters, and optimal protocol of PBM in the treatment of IAN paresthesia/dysesthesia associated with maxillofacial surgical procedures.

2. Materials and Methods

2.1 Protocol and registration

This review is based on the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement: updated guidance and examples for literature and systematic reviews.

The research question was formulated according to the PICO model: "In adult patients with IAN NSD following maxillofacial surgical procedures (third molar extraction, orthognathic surgery, implant placement, and mandibular fractures), is photobiomodulation/LLLT, compared to conventional treatment or control, more effective in objective neurosensory tests and/or VAS, improving quality of life, number of sessions, and clinical parameters?"

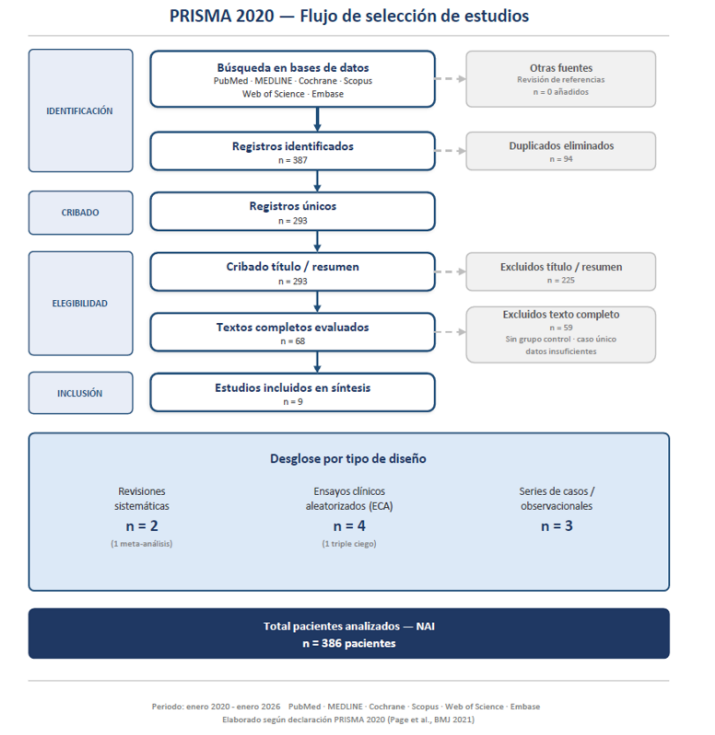

Figure 1. PRISMA 2020 flow diagram.

NSD: neurosensory deficit. IAN: inferior alveolar nerve. RCT: randomized clinical trial.

2.2 Information sources and search strategy

This review was conducted by 2 independent authors, performing searches in the PubMed/MEDLINE, Cochrane Library, Scopus, Web of Science, and Embase databases, covering the period January 2020 – January 2026, with no language restriction. The search strategy used MeSH terms: ("Photobiomodulation" OR "Low-level laser therapy" OR "LLLT" OR "PBM" OR "phototherapy" OR "laser biostimulation") AND ("inferior alveolar nerve" OR "IAN" OR "mandibular nerve" OR "nerve paresthesia" OR "neurosensory deficit") AND ("third molar" OR "wisdom tooth" OR "mandibular third molar" OR "tooth extraction"). This was supplemented by manual reference review, free-term searches, and bibliographic list searches from included articles. For epidemiological contextualization, references prior to 2020 were included when relevant.

2.3 Eligibility criteria

Inclusion criteria were based on the PICOS strategy, as described below:

Population (P): adult patients with IAN NSD following maxillofacial surgical procedures

Intervention (I): photobiomodulation/LLLT

Comparator (C): placebo, untreated control group, or conventional treatment

Outcomes (O): primary (improvement in objective neurosensory tests and/or VAS) and secondary (quality of life, number of sessions, technical parameters).

2.4 Selection criteria

Inclusion criteria:

- Human studies
- Articles that directly address the research question.
- Articles no more than 6 years old.
- Studies with quantified measurement of neurosensory recovery using VAS and/or objective neurosensory tests (two-point discrimination, static touch, pinprick test, thermal or directional discrimination);
- Articles with English or Spanish as primary language.

Exclusion criteria:

- Single case reports;
- Animal model studies.
- Articles evaluating high-power (ablative/surgical) laser.
- Articles with insufficient data
- Editorial comments or opinion articles.
- Articles without a control group or without quantified outcome measurement.

2.5 Selection process

The search initially identified 387 articles, which were entered into the virtual tool Rayyan (https://new.rayyan.ai) for duplicate removal (n=94). Following title/abstract screening (n=293), 68 articles were selected for full-text reading. Finally, 9 studies met the aforementioned criteria: 2 systematic reviews (one with meta-analysis), 4 RCTs, 2 prospective case series/observational studies, 1 non-randomized clinical study. The included studies represent a total of 386 patients with IAN NSD evaluated. These are represented in Figure 1 via the flow diagram.*https://new.rayyan.ai*

The process and analysis were conducted by 2 reviewers independently. In case of disagreement, articles were analyzed jointly according to the previously established criteria, as well as the relevance of the study and its correlation with the research question and objectives.

2.6 Data collection and synthesis

Data extraction was performed independently by two reviewers using a standardized form. Information collected included author, year of publication and journal, study type, sample size, NSD etiology, laser parameters used (wavelength, power, fluence, time per session, number of sessions, weekly frequency, application route), neurosensory evaluation tools, reported outcomes, and follow-up period.

Methodological quality of randomized clinical trials was assessed using the Cochrane RoB 2.0 tool, while systematic reviews were evaluated with AMSTAR-2.

Due to the significant clinical and methodological heterogeneity among studies, primarily in etiology, wavelength, protocol, and outcomes, a qualitative narrative synthesis was performed, complemented by quantitative data from the available meta-analysis.

3. Results

3.1 Search results

This literature review synthesized information from 9 articles published between 2020 and 2026, including a total of 386 patients who underwent dental surgical treatments resulting in subsequent IAN NSD. The varied study designs included RCTs, case series, observational studies, non-randomized clinical studies, and cohort studies. The characteristics of the included studies are summarized in Table 1.

Table 1. Summary of studies included in the systematic review.

Author / Year	Type	N / NSD Etiology	Laser parameters	Protocol	Primary outcome
Qi et al., 2020 (Lasers Dent Sci)	Case series + pilot	n=12; post-3M extraction	808 nm (NIR), 200 mW	10 J/cm², periapical and intraoral; 10 sessions	Objective and subjective NSD improvement; VAS and two-point discrimination with significant progress
Hakimiha et al., 2020 (J Lasers Med Sci) si	Case series	n=8; post-3M extraction and implants	810 nm diodo, 200 mW	10 J/cm² / point; 10 sessions 3×/ week	VAS and pinprick test improvement in all patients
Bozkaya et al., 2020 (Photobiomodul Photomed Laser Surg) si	ECA	n=40; IAN and LN injury after dental procedure	660/808 nm, 100 mW	10 sessions; extraoral and intraoral	Significant recovery in laser group vs control; greater effect on IAN than lingual nerve
Hakimiha et al., 2021 (Quintessence Int) si	Systematic review	7 studies (3 RCTs, 1 observational, 3 series); 3M + implants	Multiple (660–830 nm)	Variable; 2 days to 4 years post-injury	Better recovery in <6 months and younger patients; insufficient evidence for standard protocol
Salari et al., 2022 (J Photochem Photobiol B) si	Triple-blind RCT	n=34; neurotmesis from mandibular fracture	810 nm diodo, 200 mW	12 sessions, 2×/ week, 16 points 30 sec each	Significant improvement in discrimination tests, static touch, and pain (VAS) vs placebo

Table 1. *Continued...*

Ma et al., 2023 (PLoS ONE) no	SR + Meta-analysis	15 studies (14 for meta-analysis); 3M, orthognathic surgery, fracture	Multiple (630–830 nm)	Variable; mostly 8–12 sessions	PBM has significant therapeutic effect on IAN ($p<0.05$); VAS, 2-point discrimination, and touch with improvement
Ebrahimi et al., 2024 (J Dent Shiraz) si	Single-blind RCT	n=39; IAN injury from dental procedures	810 nm vs 940 nm diodo	12 sessions 3×/ week; complete CNT	810 nm superior to 940 nm in sensory recovery ($p<0.05$); both improve over baseline
Yari et al., 2024 (Photobiomodul Photomed Laser Surg) si	ECA triple ciego	n=34; chronic NSD >6 months post-3M extraction	810 nm diodo, 200 mW	12 sessions 2×/ week; 16 points 30 sec; 9-month follow-up	Significant improvement in VAS, static touch, 2-point and thermal discrimination vs placebo; effect maintained at 9 months
Zeytinoğlu et al., 2026 (J Clin Med) si	Non-randomized clinical study	n=NR; IAN and LN post-3M extraction	LLLT (660/810 nm)	Comparison LLLT vs TENS vs placebo	LLLT with greater clinical improvement than TENS or placebo; greater effect on lingual nerve than IAN

RCT: randomized clinical trial; NSD: neurosensory deficit; IAN: inferior alveolar nerve; LN: lingual nerve; 3M: third molar; NIR: near-infrared; CNT: complete neurosensory testing; VAS: visual analog scale.

3.2 Epidemiology of IAN NSD

Scientific evidence published during the analyzed period consolidates an incidence of transient IAN NSD following third molar extraction in a range of 0.26%–8.4%, with permanent NSD in 0.1%–2% of cases. In this context, Pippi et al. (2022), in a prospective observational study published in the Journal of Oral and Maxillofacial Surgery, identified that proximity of the root apex to the inferior dental canal on CBCT, patient age, and prolonged surgical time constitute the main independent predictors of NSD [1]. A retrospective study of 172 extractions (2021–2022) confirmed through multivariate logistic regression that age, number of fractured roots, impaction angle (40°–70°), CEJ distance (>10 mm), and curved roots are independent risk factors [7].

The Sunderland classification remains the primary reference for estimating prognosis of IAN injuries, as it relates degree of damage to the potential for functional recovery. In general, grade I injuries (neuropraxia) tend to resolve spontaneously within days to weeks, while grade II and III injuries, characterized by partial axonal compromise, may require several months for recovery. In contrast, grade IV and V injuries present more severe structural damage and less favorable prognosis, making them those that potentially benefit most from targeted therapeutic interventions, including PBM [4]. Consistent with this approach, the review by Selvi et al. (2022) notes that, while sensory nerve injuries do not constitute a surgical emergency as motor injuries do, close clinical follow-up and timely initiation of therapeutic strategies are essential when there is no evidence of spontaneous recovery during the first weeks of evolution [2].

3.3 Efficacy of PBM

The systematic review with meta-analysis by Ma et al. (2023) constitutes the highest methodological evidence available on the use of photobiomodulation in the treatment of IAN neurosensory deficit. The study gathered 15 investigations, of which 14 were included in the meta-analysis, encompassing patients with IAN injuries secondary to third molar extraction, orthognathic surgery, and mandibular fractures [11].

Overall, results showed that low-intensity PBM, applied via laser or LED, is associated with better neurosensory recovery compared to control groups. Improvements were consistent across different clinical outcomes, including the visual analog scale (VAS), two-point discrimination, tactile sensitivity, and directional discrimination, reaching statistically significant differences in all of them ($p<0.05$) [11]. However, these results must be interpreted with caution. Methodological assessment using the ROB tool showed moderate-to-high heterogeneity (I^2 variable by outcome), attributed mainly to differences in technical application parameters such as wavelength, energy dose, and number of sessions, in addition to variability in the neurosensory evaluation tools used by included studies [11]. Consequently, the authors concluded that while PBM appears to favor IAN neurosensory deficit recovery, RCTs with standardized protocols are still needed to strengthen the quality of available evidence [11].

The systematic review by Hakimiha et al. (2021), published in Quintessence International, included 7 studies (3 RCTs, 1 observational study, and 3 case series) evaluating photobiomodulation in patients with IAN NSD secondary to third molar extraction or implant placement [12]. Overall, the analyzed evidence suggests that timing of therapy initiation is one of the main determinants of neurosensory recovery, with better results observed when PBM is started within the first 6 months after injury. Additionally, younger patients showed more favorable evolution, reinforcing the role of regenerative capacity as a prognostic factor [12].

However, the authors noted that interpretation of these results must be undertaken with caution, as most included studies had small sample sizes and lacked an adequate control group, making it difficult to differentiate the therapeutic effect of PBM from the spontaneous recovery inherent to many IAN injuries [12]. Consequently, they concluded that, while available evidence supports a possible clinical benefit of photobiomodulation, the limited methodological quality of studies prevented establishing definitive conclusions about its efficacy. This review highlighted the need for RCTs with greater methodological rigor and standardized protocols, an aspect that began to be addressed in research published in subsequent years [12].

Clinical trials published between 2020 and 2026 show consistent results in favor of photobiomodulation in IAN neurosensory deficit recovery. One of the first controlled studies of the period, conducted by Bozkaya et al. (2020), evaluated 40 patients with IAN and/or lingual nerve NSD following dental procedures, randomized to PBM (660/808 nm) vs. control, which demonstrated that PBM favors significantly greater neurosensory recovery than conventional treatment, with a more pronounced effect on the IAN than the lingual nerve. Furthermore, the authors noted that the combination of intraoral and extraoral applications could optimize the clinical response [13].

Regarding treatment parameters, Ebrahimi et al. (2024) directly compared wavelengths of 810 nm vs 940 nm in 39 patients with IAN NSD from dental procedures, over 12 sessions (3 times/week), observing significantly superior sensory recovery with 810 nm [14]. This result is consistent with experimental evidence attributing to this wavelength greater tissue penetration capacity and specificity for cytochrome c oxidase, favoring nerve regeneration processes.

Favorable results were also observed in smaller sample size studies. Qi et al. (2020) evaluated photobiomodulation with 808 nm near-infrared laser in 12 patients with IAN neurosensory deficit following third molar extraction. After 10 sessions, the authors described improvement in both subjective symptom perception, evaluated by VAS, and two-point discrimination, with clinical follow-up of up to 6 months [15]. Consistently, Hakimiha et al. (2020) applied a protocol of 810 nm, 200 mW, and 10 J/cm² over 10 sessions in a series of eight patients, observing favorable evolution in pinprick testing and subjective assessment using VAS [16]. Although both studies lack large samples and robust control groups, their results provide consistent preliminary clinical evidence on the possible benefit of PBM in neurosensory recovery.

Finally, Zeytinoğlu et al. (2026) provided comparative evidence against other physical modalities by demonstrating that photobiomodulation was superior to transcutaneous electrical nerve stimulation (TENS) and placebo in neurosensory recovery following trigeminal nerve injury, although the effect was more pronounced in the lingual nerve than in the IAN [17]. Together, these studies support the use of PBM as a safe and promising therapeutic alternative for the treatment of IAN neurosensory deficit. However, differences in application protocols, evaluation tools, and characteristics of the studied populations continue to limit the possibility of establishing a standardized clinical protocol.

3.4 Technical application parameters: synthesis and recommendations

Table 2. Technical photobiomodulation parameters reported in the literature 2020–2026.

Parameter	Reported range	Most common value	Evidence level
Wavelength	630–940 nm	808–810 nm (GaAlAs NIR diode)	Moderate
Output power	70–300 mW	100–200 mW	Moderada
Energy density (fluence)	4–100 J/cm²	10 J/cm² per point	Low-Moderate
Time per point	20–60 sec	30 seg	Low
No. of points per session	4–20 points	16 points (intra + extraoral)	Baja
Session frequency	2–3 sessions/week	2 sessions/week	Moderate
Total sessions	8–15 sessions	10–12 sessions	Moderate
Onset post-injury	2 days to >6 months	<6 months (better prognosis)	High
Application routes	Intraoral and/or extraoral	Both (combined)	Low-Moderate

NIR: near-infrared; GaAlAs: Gallium Aluminum Arsenide (most common semiconductor diode); J/cm²: joules per square centimeter (fluence or energy density); mW: milliwatts.

The synthesis of protocols used in included studies allows recognition of some common trends, although methodological heterogeneity prevents establishing a definitive therapeutic scheme. The 808–810 nm wavelength, corresponding to GaAlAs diode lasers in the near-infrared spectrum, was the most frequently used and concentrates most of the available clinical evidence. Similarly, fluence of 10 J/cm² per point was the most frequently reported value; however, the wide range described across studies (4 to 100 J/cm²) reflects the lack of consensus on optimal dosing. Some protocols used combined intraoral (posterior alveolus, mandibular body) and extraoral (chin region, inferior mandibular border) applications, distributed over up to 16 points along the anatomical course of the IAN to maximize coverage of the affected nerve tissue. Regarding frequency, schemes of 10 to 12 sessions administered twice weekly over approximately 6 weeks were the most evaluated in included clinical trials. Finally, PBM initiation within the first 6 months after injury was associated with more favorable neurosensory evolution, although benefits in patients with chronic disturbances have also been documented.

3.5 Neurosensory evaluation

Table 3. Neurosensory tests used in included studies.

Neurosensory test	Type	Parameter assessed	Use in included studies
VAS (0–10)	Subjective	Intensity of sensory disturbance / pain	Universal (100% of studies)
Pinprick test	Objective	Sharp stimulus discrimination	High frequency
Two-point discrimination	Objetive	Spatial resolution threshold	Alta frecuencia
Static touch test (Semmes-Weinstein monofilaments)	Objetive	Tactile detection threshold	Moderate frequency
Directional discrimination (stroke)	Objetive	Directional perception	Moderada frecuencia
Thermal discrimination (cold/heat)	Objetive	A-delta and C fiber function	Low frequency
Trigeminal evoked potential	Electrophysiological	Objective nerve conduction	Very low frequency

VAS: visual analog scale. Objective tests ordered from highest to lowest technical complexity to administer in clinical practice.

The heterogeneity of tools used to evaluate neurosensory function constitutes a relevant limitation of available evidence. Although the visual analog scale (VAS) was the most frequently used instrument, its subjective nature alone does not allow attributing observed changes to objective functional recovery. For this reason, its application should be supplemented with standardized neurosensory tests, such as two-point discrimination, Semmes-Weinstein monofilaments, and the pinprick test. Systematic incorporation of these evaluations would allow more precise quantification of IAN sensory evolution and facilitate comparison of results across future studies [12].

3.6 Safety and quality of life impact

Regarding safety, none of the included studies reported adverse effects attributable to photobiomodulation during IAN neurosensory deficit treatment. In general, PBM was described as a painless and well-tolerated intervention, with no local or systemic complications during reported follow-up periods. Regarding oral health-related quality of life, a study published in the Journal of Clinical Medicine in 2024 evaluated this outcome using the OHIP-14 questionnaire (Oral Health Impact Profile-14). Patients treated with PBM showed better evolution in the domains of physical pain, psychological discomfort, and functional limitation compared to untreated controls [19]. Although these results suggest a favorable effect beyond sensory recovery, available evidence on quality of life remains limited and requires confirmation in studies with larger sample sizes and standardized follow-up.

4. Discussion

This systematic review synthesizes evidence published between 2020 and 2026 on the use of photobiomodulation in the treatment of IAN neurosensory deficit (NSD) in the context of oral and maxillofacial surgery, including third molar extraction, bilateral sagittal split osteotomy (BSSO), dental implant placement, and surgical treatment of traumatic mandibular fractures. Overall, included studies suggest that PBM may favor neurosensory recovery, particularly through use of diode lasers in the 808–810 nm range. This finding is supported by the systematic review with meta-analysis by Ma et al. (2023) and by randomized clinical trials reporting improvements in subjective and objective outcomes, such as the visual analog scale, two-point discrimination, tactile sensitivity, and thermal perception. However, heterogeneity of protocols, populations, and evaluation tools limits the certainty of these conclusions and prevents, for now, establishing a universal therapeutic scheme.

A fundamental aspect of this review is its etiological scope. Unlike previous publications focused exclusively on third molar surgery, included studies encompass four distinct clinical contexts of IAN injury: extraction of impacted third molars, bilateral sagittal split osteotomy (BSSO) in orthognathic surgery, dental implant placement in the posterior mandibular region, and treatment of traumatic mandibular fractures[11,12,16,18]. This etiological diversity reinforces the hypothesis that PBM acts on pathophysiological mechanisms common to peripheral nerve injury—regardless of cause—and broadens its potential clinical application in oral and maxillofacial surgery.

The study by Salari et al. (2022) deserves special consideration. It is the only triple-blind randomized clinical trial included that evaluated PBM in patients with IAN neurotmesis—Sunderland grade V—secondary to traumatic mandibular fracture, representing the most severe type of nerve injury. In this context, where spontaneous recovery is unlikely without active treatment, PBM demonstrated significant improvement in two-point discrimination, static touch, and pain (VAS) vs placebo, administering 12 sessions with 810 nm and 16 application points. This finding suggests that PBM could act as adjunctive therapy even in severe injuries, favoring distal axonal regeneration and modulating the neuroinflammatory response of the nerve stump [18]. However, as this is a single study with a small sample (n=34), its results require confirmation in larger trials.

In the field of orthognathic surgery, the meta-analysis by Ma et al. (2023) included studies with patients with post-BSSO NSD alongside other etiologies, confirming that the beneficial effect of PBM is maintained in this subgroup[11]. BSSO generates IAN injuries through stretching, contusion, or partial sectioning during osteotomy, mechanisms that produce Sunderland grade II–IV injuries more frequently than third molar extraction. Early PBM application could favor remyelination and accelerate functional recovery in these patients. Regarding dental implants, Hakimiha et al. (2020, 2021) included patients with NSD associated with mandibular implants in their investigations, observing neurosensory improvement comparable to that of post-extraction patients [12,16]. Since IAN compression by the implant or drilling heat typically generates grade I–III injuries, the potential for recovery with PBM in these cases could even be greater than that observed in fracture or partial section injuries.

One of the most clinically relevant aspects is the optimal therapeutic window. The review by Hakimiha et al. (2021) and several included studies identified more favorable evolution when PBM was initiated during the first 6 months after injury. This association may be related to the greater regenerative potential of the peripheral nerve during initial repair phases. However, the triple-blind trial by Yari et al. (2024) showed significant improvements in patients with NSD of more than 6 months duration, with benefits maintained throughout follow-up. This result broadens the potential field of PBM application and suggests that injury chronicity should not be considered, by itself, a criterion for therapeutic exclusion. Nevertheless, evidence on its efficacy in late injuries remains limited and requires confirmation in larger studies.

Wavelength also appears to play an important role in the clinical response. Ebrahimi et al. (2024) observed superior sensory recovery with 810 nm compared to 940 nm. This result may be explained by the greater affinity of the 810 nm wavelength for mitochondrial cytochrome c oxidase and its greater penetration capacity in bone and soft tissues of the mandibular region. The finding is also consistent with the predominant use of the 808–810 nm range in included studies. However, since this comparison comes from a single trial with a small sample, it is not possible to definitively conclude that 810 nm is superior to other wavelengths. Rather than establishing a closed recommendation, results allow identifying this range as that which concentrates most of the available clinical evidence.

Interpretation of results must also consider the possibility of spontaneous IAN recovery. Most first and second Sunderland grade injuries can improve naturally during the weeks or months following the procedure. For this reason, studies without control groups or with insufficient follow-up may overestimate the effect attributable to PBM. Placebo-controlled clinical trials, such as those by Yari et al. (2024) and Salari et al. (2022) [18], provide greater capacity to control this factor and contribute stronger evidence in favor of the intervention. However, differences in injury etiology and participant characteristics make it difficult to directly extrapolate their results to all cases of post-extraction neurosensory deficit.

Another relevant finding is the safety profile of PBM. None of the included studies reported adverse effects attributable to treatment, and the intervention was described as painless and well tolerated. These characteristics make it an attractive alternative within the conservative management of neurosensory deficit, especially when invasive procedures are to be avoided. Furthermore, preliminary results on quality of life suggest possible benefits in physical pain, psychological discomfort, and functional limitation. However, these outcomes were evaluated in few studies, making it currently impossible to determine with certainty the magnitude of their clinical impact.

From a practical clinical perspective in the context of oral and maxillofacial surgery, PBM offers practical advantages: it can be applied on an outpatient basis, requires neither anesthesia nor incisions, and presents no known pharmacological interactions in the analyzed studies. The most common protocols involved 10 to 12 sessions administered 2 or 3 times per week, through intraoral, extraoral, or combined applications. However, its incorporation into clinical practice depends on the availability of adequate equipment, professional training, and the ability to ensure treatment adherence. Therefore, before considering its systematic implementation, clearly defined and reproducible protocols are needed.

The main limitation of this review lies in the clinical and methodological heterogeneity of included studies. Differences were observed in NSD etiology, injury duration, irradiation parameters, number of sessions, application routes, evaluation instruments, and follow-up periods. Furthermore, several studies had small samples and observational or case series designs, which increases risk of bias and reduces estimation precision. This variability prevented conducting a proprietary meta-analysis and makes it difficult to determine what portion of the observed benefit is due to the specific effect of PBM, natural injury evolution, or other prognostic factors such as age and time elapsed since nerve damage.

The possible existence of publication bias must also be considered, as studies with favorable results are more likely to be published than those with negative or inconclusive results. Added to this is the limited standardization of neurosensory outcomes and the limited evaluation of patient-centered variables, such as quality of life, satisfaction, and functional recovery. Consequently, the findings of this review should be interpreted as favorable but still insufficient evidence to formulate high-certainty clinical recommendations.

In summary, PBM emerges as a safe and potentially effective intervention for promoting IAN neurosensory recovery across diverse maxillofacial etiologies —third molar extraction, BSSO, implants, and mandibular fractures—, both in recent injuries and chronic cases [11,12,16,18]. The 808–810 nm range and 10 to 12 session protocols are the most studied but do not yet constitute a definitive standard. Future multicenter clinical trials should compare homogeneous protocols with etiology-specific subgroups, incorporate placebo groups, use standardized neurosensory tools, and maintain follow-ups of at least 12 months. Only through studies of greater rigor will it be possible to define the optimal dosage per etiology, establish the most favorable therapeutic window, and identify which patients are most likely to benefit from this intervention.

5. Conclusions

Available evidence suggests that photobiomodulation, particularly with diode lasers in the 808–810 nm range, may favor IAN neurosensory recovery in four contexts of oral and maxillofacial surgery: third molar extraction, bilateral sagittal split osteotomy (BSSO), mandibular dental implant placement, and traumatic mandibular fracture with IAN injury. Results are consistent across both subjective and objective measures and show benefits in recent injuries and, preliminarily, also in chronic cases. However, the magnitude of the effect must be interpreted with caution due to protocol heterogeneity, small sample sizes in several studies, and the possibility of spontaneous nerve recovery.

The most commonly used schemes include powers of 100–200 mW, fluences of approximately 10 J/cm² per point, and 10 to 12 sessions, with intraoral, extraoral, or combined applications.

However, these parameters cannot yet be considered a definitive protocol. Similarly, while treatment initiation within the first 6 months and younger patient age are associated with more favorable evolution, it is still not possible to precisely establish which patients obtain the greatest benefit.

In terms of safety, PBM was well tolerated and no adverse effects attributable to the intervention were reported in included studies. Additionally, some findings suggest improvement in oral health-related quality of life. Together, these results position photobiomodulation as a non-invasive and promising therapeutic alternative, though still supported by evidence of limited certainty. Randomized, multicenter clinical trials with standardized protocols, comparable neurosensory assessments, and extended follow-up are required to define its clinical efficacy, optimal dosage, and incorporation into clinical practice guidelines.

Ethics Statement and Conflict of Interest

An ethics declaration is not applicable for systematic reviews based on published literature. The author declares no conflicts of interest and has received no external funding for this work.

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