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Posted Date: 6 March 2026

doi: 10.20944/preprints202603.0527.v1

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Effectiveness of Laser Photobiomodulation in the Treatment of Orofacial Paresthesias—Experience from a University Clinic

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Abstract

Objective: To identify the clinical effectiveness of laser photobiomodulation in the treatment of orofacial paresthesia in a public university clinic in Northeast Brazil. **Methods:** A retrospective, observational study was conducted using secondary data from 125 patients treated at the Biophotonics Center of the Faculty of Dentistry of the Federal University of Bahia from 2003 to 2019 with a confirmed diagnosis of orofacial paresthesia. Data collection included the sociodemographic profile, clinical and dental history, and the patients' main complaint. The therapeutic protocol employed an infrared diode laser (λ 700–808 nm), in continuous mode, with applications every 48 hours, totaling 12 individualized sessions. Nerve sensitivity was measured in each session using the Visual Analogue Scale (VAS), with pain reduction and movement considered as response variables. The data were analyzed, and the study was approved by the ethics committee of FOUFBA (protocol 60327516500005024). **Results:** Tooth extraction was identified as the main etiological factor of paresthesia (60%), with an average of three treatment cycles per patient. At the end of the intervention, 67% of individuals achieved satisfactory results, with significant clinical improvement or total remission of symptoms. Cases resulting from orthognathic surgery required higher cyclic doses, although no statistically significant difference was found between dosage and clinical outcome. Laser photobiomodulation proved to be an effective and viable therapeutic modality for sensory recovery and management of orofacial paresthesias.

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Introduction

Oral health problems negatively impact daily performance and quality of life. Orofacial sensory disturbances, such as paresthesia, compromise essential functions, including phonation, mastication, and social interaction [1,2]. Paresthesia is a neurosensory disorder resulting from nerve injury that occurs after a dental intervention and leads to prolonged loss of sensitivity in a specific region of the face, along with other symptoms, and may resolve spontaneously after a few days or months. Still, depending on the extent and type of nerve injury, this damage may be permanent. [2,3]

These neurosensory disorders frequently result from dental interventions, such as third molar extractions [3], implant placement [4,5], local anesthesia [6,7], and orthognathic surgeries [8], as well as facial trauma [9]. The management of these conditions is challenging due to the persistence of symptoms. Frequently, conventional therapies — drug, surgical, or physiotherapy — fail to provide adequate relief [5,7,9], prompting the need for alternatives such as laser photobiomodulation.

Laser photobiomodulation can optimize quality of life and reduce healthcare costs. Although its effectiveness is documented [11,15,16,20,22], the impact on quality of life and population

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effectiveness has not been investigated. Given this gap, this study aims to evaluate the effectiveness of defined phototherapeutic protocols in the treatment of orofacial paresthesias.

Methods

A cross-sectional, retrospective observational study was conducted, based on the analysis of clinical records of patients undergoing laser photobiomodulation for the treatment of orofacial paresthesia (ICD-10: R20.2). The research setting was the Laser Clinic of the Biophotonics Center of the Faculty of Dentistry of the Federal University of Bahia (FOUFBA), in Salvador-BA, covering the period from 2003 to 2019.

The study population consisted of individuals aged 18 to 90 years, referred by dental clinics or spontaneously through the Unified Health System (SUS). All patients with a prior diagnosis of orofacial paresthesia and who had a complete clinical record were included. Individuals who did not consent to participate or who abandoned treatment before completing a therapeutic cycle (12 sessions) were excluded. Records with incomplete or unlocatable data were also discarded. The database was structured in Microsoft Excel®, and after applying the specific filter for R20.2 (ICD-10), the study population totaled 387 cycles corresponding to 125 patients.

The research was approved by the Research Ethics Committee of FOUFBA (CONEP: 60327516500005024). In compliance with CNS Resolutions 466/12 and 510/16, all participants signed the Informed Consent Form (ICF). Biosafety protocols included the use of Personal Protective Equipment (PPE), rigorous asepsis, compliance with safety standards for laser technology, and the use of specific protective eyewear for the wavelength used, along with adequate signage in the clinical environment.

Experienced professionals conducted the assessments in a standardized outpatient setting. Data collection included anamnesis, extra- and intraoral clinical examinations to identify orofacial paresthesia, and evaluation of nerve sensitivity using the Visual Analogue Scale (VAS). The independent variables collected were: Sociodemographic: Gender and age (categorized by median: 19 to 83 years). Clinical: Etiology, medical/dental history, comorbidities, and use of adjuvant drugs (B complex vitamins and anti-inflammatories). The period was dichotomized by median into 2003–2014 and 2015–2019 for trend analysis.

Photobiomodulation protocols were individualized based on clinical severity under the supervision of the clinic's coordinator. Data on Dose per Session (DS), Cyclic Dose (CD), number of sessions, laterality, and wavelength (λ) were recorded. The outcome analysis was based on VAS evolution, categorizing results as "asymptomatic" (complete sensory reestablishment), "improvement," or "symptomatic" (persistence of the condition). From 2018 onwards, retrospective observations were complemented by direct contact between the researcher and the patients, thereby validating the tabulated data.

Clinical Characterization and Etiological Variables: The injured nerve component was determined based on the main complaint and the topography of the symptomatology. Cases involving the inferior alveolar nerve (IAN) included paresthesias in the lower lip, chin, and body of the mandible. At the same time, sensory alterations in the tongue identified lesions in the lingual nerve (NL). The etiology was established through dental history, categorizing the episodes as resulting from tooth extractions, implant placements, orthognathic surgeries, or facial trauma. Additionally, medical history information allowed stratification of individuals by comorbidities and the use of adjuvant drugs, specifically vitamin B complexes and anti-inflammatory medications, to reduce edema and facilitate nerve decompression.

Dosimetric Parameters and Therapeutic Protocols: The therapeutic regimen consisted of 12-session cycles. For analysis purposes, treatment was classified as a "complete cycle" for those who completed all 12 applications and "incomplete/abandonment" for cases of premature interruption. Dosimetry was analyzed from two perspectives: Dose per Session (DS), defined as the sum of the doses applied at each point in each treatment, and Cyclic Dose (CD), calculated by multiplying DS by the total number of sessions (CD = DS x Total Sessions). Due to the retrospective nature of the

 doi:10.20944/preprints202603.0527.v1

secondary data, the number of application points and the specific point dose were not individualized in the database.

Sensory evolution was monitored subjectively using the inverted Visual Analogue Scale (VAS). Patients quantified their sensitivity and discomfort in each session, assigning values from 0 to 10. The outcome was determined by the predominant numerical frequency throughout the 12-session cycle, categorizing the results as: Asymptomatic (Scores 8 to 10): Restoration of sensitivity and absence of discomfort; Improvement (Scores 6 to 7): Satisfactory clinical evolution, but with the presence of residual symptoms; Symptomatic (Scores 0 to 5): Persistence of paresthesia and absence of sensitivity. Individuals who interrupted treatment for more than 30 days were classified as "dropouts". For inferential analyses, the categories "asymptomatic" and "improvement" were combined to represent therapeutic success (Figure 1).

Statistical processing was performed using Minitab® Release 14 software. Descriptive statistics were employed for categorical variables (frequencies) and for quantitative variables (mean, median, and standard deviation). The association between independent variables and clinical outcomes was tested using the Chi-square (χ^2) test and Analysis of Variance (ANOVA), adopting a significance level of $p<0.05$.

Results

According to Table 1, 125 patients were treated: 52% between 2003 and 2014 and 48% between 2015 and 2019, with an average age of 41 years. Women accounted for 76%. After evaluating the main complaint, the most frequently reported possible nerve injuries were the inferior alveolar nerve (IAN) in 76% of patients and the lingual nerve (TN) in 24%. Approximately 7% of individuals had simultaneous paresthesia in both nerves (IAN+TN).

Neurosensory disturbance was the most prevalent after exodontia (60.8%) and orthognathic surgery (13.6%) procedures. This symptomatology was also reported in 12.8% of individuals who suffered some facial trauma. Comorbidity was reported in 66.4% of patients. Regarding the use of medications to assist in the therapy of paresthesia, 22.4% of individuals used them at some point since diagnosis. Orofacial paresthesia was more frequently reported on the left side of patients (46.4%). There were also reports of bilateral numbness in 17.6% of cases—approximately 70% of the treatment was completed.

Regarding the laser light therapy protocol used in the studied population, the average doses were: Dose per session (DS) 88J/cm² and at the end of the cycle, a therapeutic or cyclic dose (DC) of 1095J/cm². Around 35 sessions were performed, corresponding to approximately 3 laser therapy cycles performed per patient (Table 1).

Table 1. Characterization of patients with Orofacial Paresthesia treated at the Laser Clinic of the Biophotonics Center of FOUFBA, Salvador - BA, 2003 to 2019. N=125.

Variables	N	%
Years		
2003 a 2014	65	52.00
2015 a 2019	60	48.00
Gender		
Female	95	76.00
Male	30	24.00
Injured nerve		
Inferior alveolar (IAN)	95	76.00
Lingual (TN)	21	16.80
Both (IAN + TN)	9	7.20
Etiology		
Tooth Extraction	76	60.80
Orthognathic Surgery	17	13.60
	16	12.80

Dental Implant Surgery	16	12.80
Facial Trauma		
Affected Side		
Right	45	36.00
Left	58	46.40
Bilateral	22	17.60
Comorbidities		
Yes	83	66.40
No	42	33.60
Medications to control paresthesia		
Yes	28	77.60
No	97	22.40
Cycles Completed		
Complete	88	70.40
Incomplete/abandoned	37	29.60
	Mean	Standart Deviation
Age	41.31	16.21
Session dose (SD) (J/cm²)	87.7	128.9
Cyclic Dose (CD) (J/cm²)	1095	1740
Total sessions	34.68	34.40
Cycles	2.76	2.85

Figure 1 shows that tooth extraction was the most prevalent cause among treated patients in both periods. In the first period (2003 to 2014), paresthesia was also present in individuals who suffered facial trauma. In the second period (2015 to 2019), also in those who underwent orthognathic surgery (20%), these data were statistically significant (p=0.002).

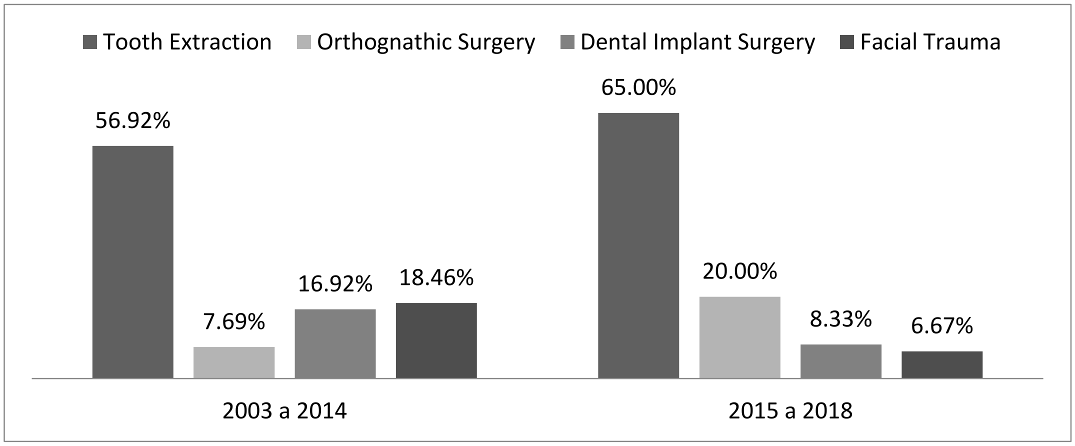

Figure 1. Causes of orofacial paresthesia in patients treated at the Laser Clinic of the Biophotonics Center of FOUFBA, Salvador – BA-Brazil, in the periods from 2003 to 2014 and from 2015 to 2019. (p=0.02 - Chi-square).

In the final analysis, approximately 67% of the 125 patients achieved a satisfactory outcome. Orofacial paresthesia persisted in approximately 17% of them, resulting in unsatisfactory outcomes and abandonment in 16%.

When analyzing the association between the studied variables and the final treatment outcome (Table 2), only the number of completed cycles (78%) was associated with a favorable outcome, with this relationship being statistically significant (p<0.001).

Both men and women obtained satisfactory results in their groups above 60%, as did the age groups, although without a statistically significant difference (p>0.05, Table 2).

 doi:10.20944/preprints202603.0527.v1

Table 2. Variables associated with the end of treatment in patients at the Laser Clinic, Biophotonics Center of FOUBA, 2003-2019. N=125.

	Positive end of treatment (+)		No positive end of treatment (-)		Abandonment		Total	p Value
Variables	N	%	N	%	N	%	N	
Gender								
Female	60	63.16	19	20.00	16	16.84	95	>0.05
Male	24	80.00	2	6.67	4	13.33	30	
Age								
19 to 37 years of age	41	64.06	12	18.75	11	17.19	64	>0.05
38 to 83 years old	43	70.49	9	14.75	9	14.75	61	
Injured nerve								
Inferior alveolar (IAN)	62	65.26	16	16.84	17	17.89	95	>0,05
Lingual (TN)	16	76.19	3	14.29	2	9.52	21	
Both (IAN + TN)	6	66.67	2	22.22	1	11.11	9	
Causes								
Tooth Extraction	47	61.84	17	22.37	12	15.79	76	>0.05
Orthognathic Surgery	14	82.35	2	11.76	1	5.88	17	
Dental Implant Surgery	11	68.75	2	12.50	3	18.75	16	
Facial Trauma	12	75.00	-	-	4	25.00	16	
Comorbities								
No	27	64.29	6	14.29	9	21.43	42	>0.05
Yes	57	68.67	15	18.07	11	13.25	83	
Medications to control paresthesia								
No	67	69.07	14	14.43	16	16.49	97	>0.05
Yes	17	60.71	7	25.00	4	14.29	28	
Cycles Completed								
Complete	69	78.47	19	21.59	-	-	88	<0.001
Incomplete/abandoned	15	40.54	2	5.41	20	54.05	37	

Regarding the injured nerves, satisfactory results were also high, at 65.26% for IAN and 76.19% for TN. Regarding medical history, there were no statistically significant differences in outcomes for the comorbidity variables or the medication-use variable for the treatment of paresthesia. However, in all groups, these variables showed favorable outcomes ($p > 0.05$; Table 2).

There was a statistically significant difference ($p=0.04$) in relation to cyclic doses and possible causes related to paresthesia (Figure 2). In individuals who had undergone orthognathic surgery, the average cyclic doses were higher (2148J/cm^2) than those who suffered facial trauma (782J/cm^2) and exodontia (889.75J/cm^2).

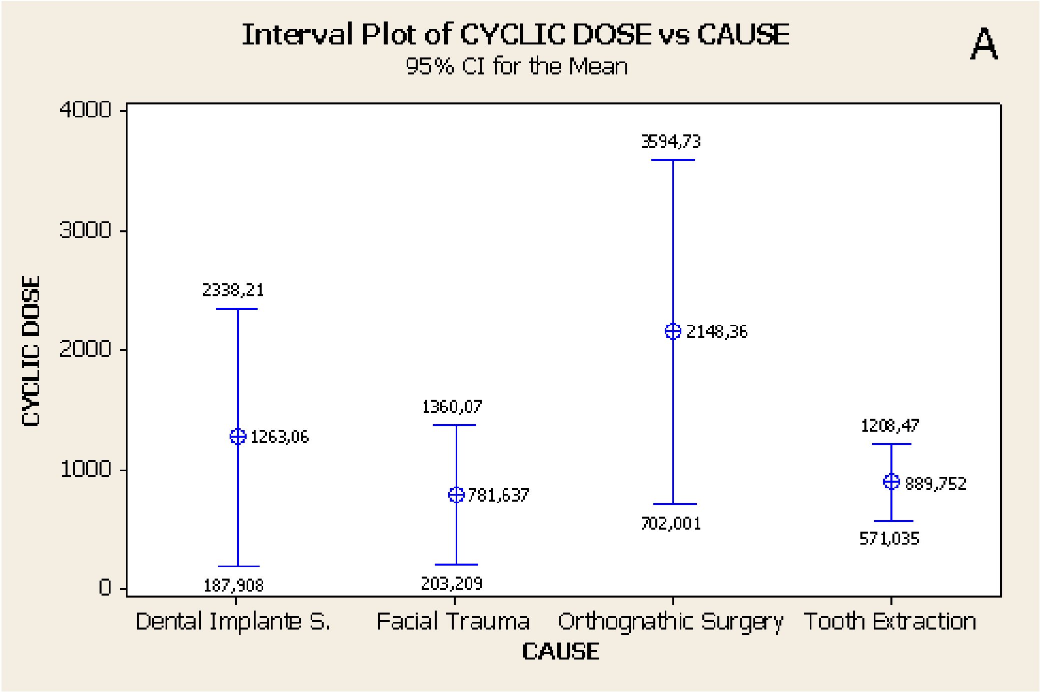

Figure 2. Mean and confidence interval of cyclic doses (J/cm²) related to the variable of causes of orofacial paresthesia (A) (p=0.04, ANOVA).

Discussion

The observed effectiveness of 67.20% with improvement in clinical condition occurred in cases adhering to the protocol of three weekly sessions with 48-hour intervals and an average cyclic dose (CD) of 1,196.7 J/cm². The adopted therapeutic interval is based on Arndt-Schultz's Law, as adapted by Ohshiro and Calderhead (1991) [14], which advocates a therapeutic window for photostimulation to avoid bioinhibition from overdose. Despite the lack of consensus on the ideal periodicity, the results corroborate models of alternating application with documented neuroregenerative effects [10,15,16].

Regarding physical parameters, the exclusive use of the infrared spectrum (λ 700–808nm) in continuous mode proved to be effective. Although experimental studies suggest the use of the red spectrum [17–23], the clinical evidence from this study aligns with investigations demonstrating the superiority or sufficiency of infrared light for deep nerve regeneration [3,13,15,16,24].

Etiologically, tooth extraction was the predominant causal factor (60.80%), with the inferior alveolar nerve being the most affected structure (76%). This scenario underscores the need for rigorous postoperative surveillance to enable early intervention [15,21,23,24]. An increase in cases after orthognathic surgery (20%) was also noted between 2015 and 2019, possibly associated with the complexity and surgical time of these procedures [23–25]. Cases of therapeutic failure may be linked to severe structural lesions, such as neurotmesis, which frequently result in irreversible paresthesias [15,22]. In contrast, the reduction in post-implant neuropathies (8.33%) suggests the positive impact of minimally invasive techniques in contemporary implant dentistry [26].

Regarding biological variables, although Gøransson et al. (2004) [27] indicate that a lower nerve fiber density in men favors neuropathies, and other authors [27,28] point out that aging limits reinnervation, this study did not observe a statistically significant difference between genders or age groups. The 73% improvement in patients aged 38-83 years suggests that senescence does not prevent the photobiomodulatory response, although this requires further investigation.

Finally, the effectiveness of the cyclic dose and the infrared spectrum differ from those of protocols that use combined spectra at low doses for diabetic neuropathies [29], suggesting that infrared monotherapy is robust for the clinical profile studied. Furthermore, the lack of statistical

 doi:10.20944/preprints202603.0527.v1

significance in the use of B-complex vitamins and anti-inflammatory drugs [30] does not negate their clinical importance. Instead, it reinforces that laser photobiomodulation served as the primary vector of sensory recovery in this case series.

In the field of molecular biology, the application of photobiomodulation — a non-pharmacological therapeutic modality — stands out for its ability to increase the gene expression of growth factors, favoring neurotissue regeneration [19,30]. In the present study, although there was no detailed information on the chronology of drug prescription or the duration of use, no statistical significance was identified in the association between drug use and clinical outcome. Notably, isolated photobiomodulation was effective in approximately 69% of patients who did not use adjuvant drug therapy.

These findings reinforce the need for further population-based research to investigate the real clinical efficacy of these medications in the management of paresthesia, whether or not associated with laser therapy. Validation of the photobiomodulation protocol as an adjuvant intervention may represent an essential strategy for reducing healthcare costs, relieving patients of the burden of pharmacological expenses, and optimizing healthcare system resources.

Conclusions

Laser photobiomodulation has proven to be an effective therapeutic modality for neurosensory recovery in patients with orofacial paresthesia, achieving satisfactory results in approximately 67% of the study population with exclusive use of the infrared spectrum. The magnitude of the cyclic dose (CD) employed influences the clinical outcome, showing a direct dependence on the etiology of the disorder - patients with a history of orthognathic surgery required significantly higher therapeutic doses to achieve clinical improvement when compared to those whose lesions resulted from facial trauma.

However, the need for new epidemiological studies with a population-based design is highlighted, aiming to improve and standardize clinical protocols for the treatment of this condition, which remains one of the most recurrent therapeutic challenges in contemporary dental practice.

Author Contributions: Amanda Silva Santos, Antonio Luiz Barbosa Pinheiro and Maria Cristina Cangussu are involved in the Conceptualization.; methodology, formal analysis; Antonio Luiz Barbosa Pinheiro acquire software, validation, resources and data curation. Amanda Silva Santos, Maria Cristina Cangussu, Jean Nunes dos Santos developed writing—original draft preparation and writing—review and editing. Jean Nunes dos Santos were the supervision and Antonio Luiz Barbosa Pinheiro - project administration, and funding acquisition. All authors have read and agreed to the published version of the manuscript.".

Funding: FAPESB (Bahia State Research Support Foundation) – research grant to the lead author (Grant Number: 0945675464).

Institutional Review Board Statement: "The study was conducted in accordance with the Declaration of Helsinki, and approved by Ethics Committee of Federal University of Bahia (protocol code 603275516.5.0000.5024 approved in 05/18/2017)." We reinforece that all data use only second data, including all medical and dental records and the coordinator of the Clinc, professor Antonio Pinheiro are included and gave his permission to acess the dataset.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study as a rule in all services provided at the university's teaching clinic.

Data Availability Statement: The original data presented in the study are openly available in the repository of the pos graduate program in dentistry and health in https://docs.google.com/spreadsheets/d/1PVTb2lxKxTPy-mx7dYUXfjQHPTLedSnH/edit?usp=sharing&ouid=106213072280853158192&rtpof=true&sd=true.

Acknowledgments: The authors have reviewed and edited the output and take full responsibility for the content of this publication. No GenIA was used.

doi:10.20944/preprints202603.0527.v1

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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