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Photobiomodulation with low-level laser as an adjuvant in the functional rehabilitation of peripheral facial paralysis

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ABSTRACT

Peripheral facial palsy represents a neurological condition with motor repercussions. Although physiotherapy is the mainstay of treatment, the evidence on the clinical efficacy of low-level laser therapy (LLLT) using photobiomodulation is still limited and heterogeneous. The primary objective is to assess the impact of low-level therapeutic laser (Class 3B) on the functional recovery of patients with peripheral facial paralysis treated at the Daniel Alcides Carrión Hospital in Huancayo, Peru. A pre-post quasi-experimental study was conducted in 41 patients with peripheral facial paralysis, of which 80.5% had Bell's palsy. The treatment consisted of photobiomodulation with low-intensity laser (1064 nm, 63 mW, 3 J/cm2, 40 s/point) applied in ten sessions. Facial function was assessed using the House-Brackmann scale before and after treatment. The data were analyzed with the Wilcoxon test ($p<0.05$). The median House-Brackmann score was reduced from 4 to 2, representing a significant improvement ($\Delta=-2$; $p<0.001$; $r=0.87$). LLLT-based photobiomodulation has proven to be safe and effective in the improvement of facial function in peripheral facial palsy, with no adverse effects. Patients with symptom duration of less than 4 weeks had significantly better functional recovery. The therapeutic effect of LLLT is supported by these results. Therefore, strict randomized controlled trials (RCTs) should be required to verify these results and provide unanimous dosimetry and frequency protocols to achieve the best clinical implementation.

Key words: facial paralysis; photobiomodulation; low-intensity laser; physiotherapy; neuromuscular rehabilitation; quasi-experimental study.

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Introduction

Facial paralysis is a neurological disease defined by having partial or complete loss of movement on one side, which can be devastating in terms of both function and expression. This may have various etiologies like Ramsay Hunt syndrome, trauma, tumors, or viral infections, but herpes simplex virus type 1 is considered the most common cause, being responsible for Bell's palsy in up to 70% of cases.[1]

Apart from motor implications, facial palsy severely impairs the psychosocial status of the patient by disturbing their ability to communicate, express emotions and confidence.[2]

The fact that it is impossible to express emotions by using facial expressions results in relevant psychological implications and a serious reduction in quality of life; this emphasizes the importance of an interdisciplinary and global approach for the rehabilitation treatment.[3]

Traditional management typically involves pharmacological therapy – most commonly various combinations of corticosteroids and antivirals – along with physiotherapy and, in some cases, surgical intervention. Nevertheless, pharmacological treatment efficacy is often limited in severe or chronic states, thus making it an essential part of recovery by means of physiotherapy in a neuromuscular disorder. This approach aims to restore facial motor activity, avoid contractures, and coordinate movement, with sustained long-term functional benefits.[4]

In this regard, the application of low-level therapeutic laser has become a new physiotherapeutic alternative. Photobiomodulation works within cells *via* bio-stimulatory effects that enhance the production of adenosine triphosphate (ATP), induce mitosis, and trigger cytokines and growth factors associated with tissue repair.[5]

It has been reported that low-level laser therapy (LLLT) promotes descriptive electrical response and neural regeneration, modulates inflammation in injured nerves, and leads to analgesic effects, all of which contribute to ensemble benefits for the functional recovery of facial nerve injuries.[6]

However, the existing evidence has several limitations. The clinical heterogeneity of patients, different application parameters (wavelength, power density, dose, and time), and the absence of controlled studies make it difficult to do comparisons between studies and establish protocols.

Without standardized metrics for evaluating facial recovery, it is not possible to arrive at a consensus based on solid evidence for therapy, and the need for more explicit and repeatable research is emphasized.

Resolution of these methodological constraints is crucial to establishing clinical guidelines that optimize laser dosimetry and permit treatment personalization, as the latter can benefit functional recovery and psychosocial outcome in facial paralysis patients.

In this context, the aim of the current research was to determine the effectiveness of Class 3B LLLT as adjuvant therapy for paralysis rehabilitation in patients with facial palsy treated at the Physiotherapy Service of Daniel Alcides Carrión Hospital (Huancayo, Peru) by evaluating changes in facial function according to the House-Brackmann scale. The results aim to serve as initial evidence that targets the effect of a therapeutic laser and the clinical quality of photobiomodulation, establishing a base for new randomized controlled trials (RCTs).

Within the Peruvian setting, literature research on facial photobiomodulation is limited, and there is a need for more applied investigations that produce local evidence. In other words, we hypothesized that LLLT may significantly improve facial function in cases of peripheral paralysis.

Although it has become increasingly evident that LLLT may stimulate neural regeneration, the optimal dosimetry and timing of its application in peripheral facial palsy remain unclear. In this view, photobiomodulation with low-level laser effectively promotes recovery of facial function and is a valuable non-invasive option for treatment in neuromuscular rehabilitation protocols.

Materials and Methods

Study design

The objective of the present article is to describe the development of a prospective and quasi-experimental quantitative study using a pre-post without control group design to evaluate changes in facial tonus after performing photobiomodulation with LLLT application. The study was conducted at the Physical Therapy Unit of Daniel Alcides Carrión Hospital (Huancayo, Peru) with clinical control. It permitted looking for an association between physiotherapy intervention and functional improvement, but did not infer a causal relationship.

Participants

The sample consisted of 41 patients diagnosed with peripheral facial palsy, selected by non-probabilistic convenience sampling. Inclusion criteria comprised a confirmed clinical diagnosis of facial paralysis, age ≥18 years, and signed informed consent. Exclusion criteria were the presence of active neoplasms, skin infections in the application area, pregnancy, concomitant neurological disorders, or abandonment of treatment before completing sessions. The mean age was 42.6±13.4 years (range: 18-71), with a predominance of females (65.9%).

Procedure

Prior to the intervention, a baseline assessment was carried out using the House-Brackmann scale. Subsequently, each participant received a standardized low-level therapeutic laser protocol (Class 3B), applied by a team of physiotherapists specialized in neurorehabilitation, neuropediatrics, and global postural re-education.

Treatment parameters

Therapeutic laser treatment was applied, differentiating the parameters according to the intensity used. For the low-intensity laser, a wavelength of 1064 nm, Class 3B, laser diode generator, with an output power of 63 mW, energy density of 3.0 J/cm^2, and an exposure time of 47 seconds per point, in point contact mode over an area of approximately 1 cm^2, was used, with a modulation frequency of 5 Hz and an average of 10 sessions.
The high-intensity laser was applied with a wavelength of 1064 nm, output power of 10 W, modulation frequency of 20 Hz, energy density of 10 J/cm^2, and an exposure time of 55 seconds per point, maintaining the point contact mode and an average of 12 therapeutic sessions distributed three times a week.
Each session included irradiation of 8 to 12 points, depending on the extent and laterality of the lesion, with a frequency of three sessions per week, totaling ten sessions per patient (total duration: 3-4 weeks). During the procedure, the use of certified protective eyewear for the operator and patient was ensured, and reflective surfaces were removed from the immediate environment.

Instruments

Facial motor function was assessed using the House-Brackmann scale, an internationally validated instrument (intraclass correlation coefficients [ICC]=0.95), which classifies facial function into six grades, from normal (I) to complete paralysis (VI). The evaluation was carried out by a trained physiotherapist who was not involved in the application of the treatment, to minimize observation biases.

Statistical analysis

The analysis was performed with IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA). The distribution of the data was verified using the Shapiro-Wilk test, and due to the absence of normality, the non-parametric Wilcoxon signed-rank test was employed to compare the pre- and post-intervention scores. A significance level of $p<0.05$ and a 95% confidence interval were adopted. Effect size was calculated using the $r=Z/\sqrt{N}$ statistic, interpreted according to Cohen's criteria (0.1=small, 0.3=medium, 0.5 or higher=large). All participants completed scheduled sessions, with no losses or adverse effects reported.

Results

Basal sample characteristics

Table 1 presents the initial demographic and clinical data of the 41 participants. Most corresponded to cases of Bell's palsy (80.5%), with a predominance of females (65.9%) and a mean age of 42.6 years. The initial House-Brackmann grade was predominantly IV (56.1%). No adverse effects associated with treatment using low-level therapeutic laser were recorded.
In the stratified analyses, the magnitude of the change in facial function did not show significant differences according to sex or etiology, although a trend toward a better response was observed in cases with a shorter time of evolution (<4 weeks).
The results showed a significant functional improvement in House-Brackmann scale scores, with a median reduction from 4 to 2 points, equivalent to the transition from moderate to mild paralysis. The decrease in the inter-

Table 1. Baseline characteristics of patients with facial paralysis treated with therapeutic laser (n=41).

Variable		Value
Age (years), mean±SD (range)		42.6±13.4 (18-71)
Sex	Female Male	27 (65.9%) 14 (34.1%)
Etiology	Bell's palsy Traumatic Other	33 (80.5%) 5 (12.2%) 3 (7.3%)
Time from baseline (weeks), median (IQR)		4 (2-6)
Initial Degree House-Brackmann	III IV V	6 (14.6%) 23 (56.1%) 12 (29.3%)
Previous treatments	Corticosteroids Antivirals Physiotherapy None	18 10 8 5
Adverse effects during therapy		Not reported

SD, standard deviation; IQR, interquartile range.

quartile range (from 2 to 1) suggests a more homogeneous response among the participants. The Wilcoxon test confirmed a statistically significant difference ($p<0.001$) with a high effect size ($r=0.87$), representing a very large magnitude of change according to Cohen's classification (Table 2).

Taken together, these findings support the efficacy of low-level therapeutic laser photobiomodulation in the facial functional recovery of patients with peripheral palsy, consolidating its potential as an evidence-based adjuvant physiotherapeutic intervention.

Table 2. Descriptive statistics and pre-post-treatment comparison.

Metric	Value
Median (pre)	4.1
SD (pre)	0.89
Media (post)	1.9
SD (post)	0.7
Medium (pre)	4
IQR (pre)	2
Median (post)	2
IQR (post)	1
Median Δ (post-pre)	−2.0
Wilcoxon *W* statistic	861
p-value (Wilcoxon)	<0.001
Effect Size (r)	0.87

SD, standard deviation; IQR, interquartile range.

Normality and hypothesis testing

The results of the Shapiro-Wilk test indicated that the scores did not follow a normal distribution ($p<0.05$), justifying the use of the nonparametric Wilcoxon test for related samples (Table 3).

The Wilcoxon test was used to determine whether there were statistically significant differences between the House-Brackmann scores recorded before and after the laser therapeutic intervention. The test results indicated a statistically significant difference ($p<.001$) between baseline and final measures. An improvement in facial function was observed after therapeutic laser treatment, evidenced by a reduction in House-Brackmann scale scores (Figure 1).

Discussion

The results of this study showed a significant improvement in facial function after the application of photobiomodulation with low-level laser, with a median reduction of two points on the House-Brackmann scale. This finding suggests a clinically relevant change from moderate to mild paralysis, with a high effect size ($r=0.87$), supporting the efficacy of photobiomodulation as an adjuvant strategy in the rehabilitation of peripheral facial paralysis.

Several recent studies have reported concordant results.

Table 3. Results of normality testing (Shapiro-Wilk) and hypothesis testing (Wilcoxon signed-rank test) for facial paralysis characteristics. The Shapiro-Wilk test indicates non-normal distribution for both pre- and post-treatment evaluations (p<0.0001). Consequently, the Wilcoxon signed-rank test was used to assess the median difference between pre- and post-treatment scores, resulting in a statistically significant rejection of the null hypothesis (p<0.0001). Significance level was set at 0.05.

Test/Step	Variable	Statistic	df	p-value	Decision
Normality test (Shapiro-Wilk)	Facial paralysis characteristics – First evaluation	0.859	41	<0.0001	Distribution is not normal
	Facial paralysis characteristics – Second evaluation	0.804	41	<0.0001	Distribution is not normal
	Null hypothesis	**Significance**			
Hypothesis testing (Wilcoxon signed-rank)	The median difference between pre- and post-treatment scores is 0.	p<0.0001			Null hypothesis is rejected

Amiri and Fekrazad (2024) showed that photobiomodulation with wavelengths between 808 and 1064 nm produces an average functional improvement of 1.5 to 2 points on the House-Brackmann scale.[7] Similarly, Kim *et al.* (2023) confirmed an acceleration of the nerve regeneration process and a decrease in pain and inflammation in patients with craniofacial neuropathies treated with low-level laser. These results support the magnitude of the change observed in the present research and strengthen its clinical relevance.[8]

From a physiological point of view, photobiomodulation acts on cytochrome c oxidase of the mitochondrial respiratory chain, increasing ATP synthesis, the release of growth factors, and the modulation of inflammatory mediators. This biochemical effect generates a favorable cellular environment for axonal repair and reorganization of the neuromuscular plate. In addition, induced vasodilation improves microcirculation and oxygen supply, accelerating the functional recovery of facial muscles. These mechanisms coincide with those reported by Hamblin.[9] The more favorable response in patients with a shorter evolution time (<4 weeks) reinforces the importance of early intervention, coinciding with what was described by Kandakurti *et al.* (2020), who pointed out that the efficacy of photobiomodulation decreases in chronic conditions due to fibrosis and incomplete axonal reor-

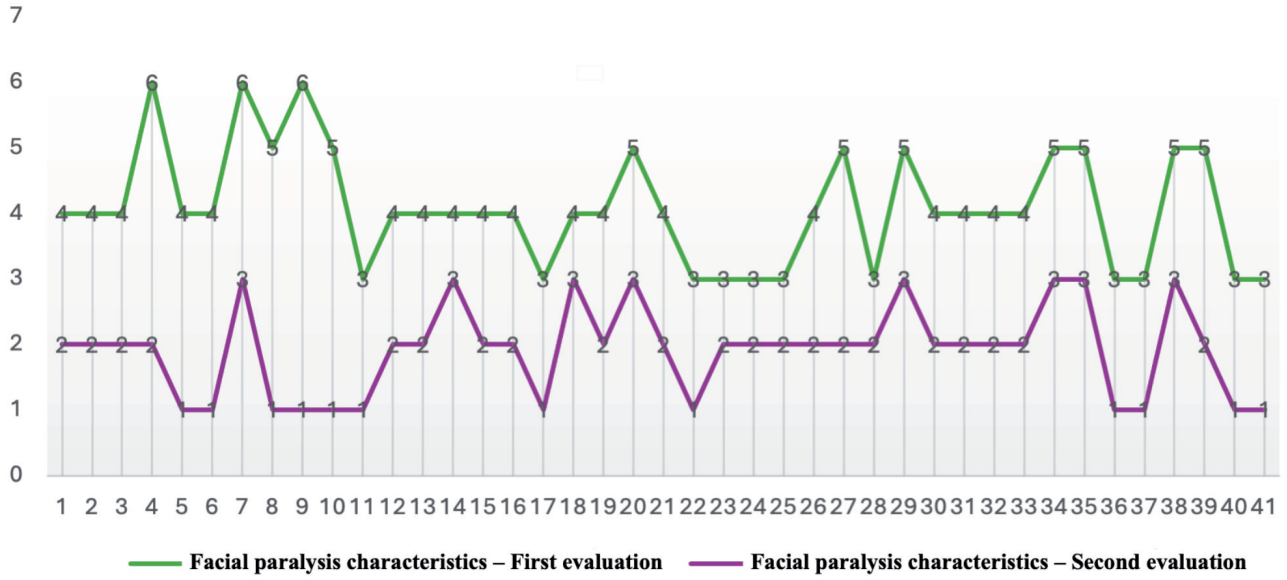

Figure 1. House-Brackmann scale.

ganization. In this sense, the early application of the laser could be considered a positive prognostic factor for neuromuscular recovery.[10]

However, interpretation of the results should be done with caution. The pre-post design without a control group limits the ability to attribute direct causality, and spontaneous recovery may have partially contributed to the observed improvement. In addition, the absence of longitudinal monitoring makes it impossible to determine the sustainability of the benefits in the long term. These methodological limitations are frequent in quasi-experimental studies and reinforce the need for RCTs with comparison groups, long observation periods, and blinding of the evaluator.

Despite these limitations, the present study provides valuable preliminary evidence on the significant improvement and safety of low-level therapeutic laser in peripheral facial paralysis. The absence of adverse effects and the magnitude of the observed functional change support its clinical applicability as a non-invasive complement in physiotherapy programs.

Collectively, these results validate the biological plausibility of photobiomodulation as a regenerative approach and are feasible to implement in standardized neuromuscular rehabilitation programs. Future research should aim at comparing different dose parameters, associating photobiomodulation with other neurofacial strategies (*e.g.*, electrostimulation, mirror therapy), and evaluating its effects on the long-term quality of life and motor function. This will lead to evidence-based clinical recommendations on physiotherapy treatment in peripheral facial palsy.

Conclusions

This non-randomized, quasi-experimental longitudinal before-and-after without control study showed that LLLT (Class 3B) was followed by a statistically significant improvement in facial function among patients with peripheral facial palsy as quantified through the House-Brackmann scale. Interestingly, the median reduction on the 10-point scale was only 2 points; however, this change is clinically meaningful, as it reflects a shift from moderate to mild paralysis. These findings confirm the significant benefit of low-intensity photobiomodulation as an adjunct to physiotherapeutic treatment in facial neuromuscular rehabilitation.

Nevertheless, the lack of a control group and potential clinical confounding are limitations to the interpretations of the conclusions. Controlled clinical trials as well as longitudinal follow-up of these individuals, are suggested to confirm the dimension and persistence of LLLT therapeutic effect.

In conclusion, the data obtained support the biological plausibility and safety of using LLLT as an adjunctive treatment for facial nerve paralysis, and underscore the need to further our understanding by developing standardized protocols that optimize dosimetry, treatment frequencies, and application sites to achieve improved clinical outcomes in the rehabilitation of facial paralysis.

The systemic integration of photobiomodulation on facial physiotherapy programs might maximize neuromuscular rehabilitation and minimize psycho-social-related sequelae. Future multicenter cohorts with longer follow-up would help us determine its cost-effectiveness and generalizability across various clinical settings.

Photobiomodulation with low-level laser (1064 nm, 3 J/cm^2) produced a significant and clinically relevant improvement in facial function in patients with peripheral paralysis. The magnitude of change observed (r=0.87) supports its use as a safe adjuvant intervention in neuromuscular physiotherapy. It is recommended to validate these results through multicenter RCTs, with prolonged follow-up and dosimetry comparisons, to establish evidence-based practice guidelines.

Contributions: Nadia Zelmia Balbin Matamoros: conceptualization, writing – original draft preparation, sources; Jessica Cinthya Loyola Zevallos: methodology; Luis Carlos Guevara Vila, Judy Janeth Canchaya Ore: formal analysis; Nadia Zelmia Balbin Matamoros, Luis Carlos Guevara Vila: investigation; Nadia Zelmia Balbin Matamoros, Judy Janeth Canchaya Ore: writing – review and editing. All the authors have read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of interest: the authors have no conflict of interest to declare.

Ethics approval and consent to participate: this study was approved by the Ethics Committee of the Universidad Continental, Official No. 0480-2024-CIEI-UC.

Written consent to participate was obtained from all study participants.

Availability of data and materials: the datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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