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Effects of phototherapy in patients with idiopathic facial palsy: Scoping review

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ABSTRACT

Phototherapy has emerged as a promising treatment for Bell's palsy, offering potential improvements in facial nerve function and overall well-being. In this study, we selected seven relevant studies involving 306 patients with subacute or acute Bell's palsy from PubMed, EMBASE, Web of Science, and Scopus before June 5, 2024. Low-level laser therapy (LLLT) efficacy for facial nerve paralysis was assessed in seven studies. Two studies lacked standard deviation data, precluding meta-analysis. Sunnybrook scores favored LLLT (mean difference [MD] = 17.42, 95 % confidence interval [CI]: 4.00–30.84, p = 0.011). However, Facial Disability Index results showed no significant difference (MD = 12.16, 95 % CI: −0.60 to 24.92, p = 0.061) between LLLT and control. LLLT, particularly with wavelengths of 830 or 850 nm administered over 6 weeks, may lead to beneficial outcomes. Combining LLLT with exercise therapy appears to be effective . LLLT demonstrates promise as a management option for Bell's palsy, potentially offering advantages over other treatments, particularly in patients with comorbidities, such as diabetes. Phototherapy devices currently used in Japan offer non-invasive treatment with minimal patient burden. The safety and therapeutic efficacy of these devices have been confirmed as a potential treatment for facial nerve paralysis.

1. Introduction

Idiopathic peripheral facial palsy, commonly known as Bell's palsy, is a sudden and unilateral syndrome that affects approximately half of the facial muscles, potentially leading to paralysis [1,2]. Given the crucial role of facial muscles in human communication, Bell's palsy can cause psychological and social challenges [1]. Furthermore, it can pose challenges in essential functions, such as eating, drinking, speaking, and closing the eyes [3].

Bell's palsy is characterized by inflammation of the peripheral facial nerve and differs from other facial palsies because it is considered an idiopathic condition [4,5]. Various factors, including infection, compression, microtrauma, autoimmune responses, and genetic predispositions, have been proposed, although the exact cause remains unknown [6,7]. Some evidence suggests that the reactivation of the herpes simplex virus-1 within the cranial nerve is a leading candidate for triggering facial nerve inflammation in Bell's palsy [8].

Various approaches have been proposed to manage Bell's palsy. Corticosteroid medications and acupuncture are commonly recommended as effective modalities [9,10]. However, a systematic review suggested that antiviral agents do not substantially contribute to the recovery of Bell's palsy [11].

Stellate ganglion block (SGB) was first introduced in the 1960s within the realm of pain clinics and is used as a treatment modality for facial nerve paralysis because of its vasodilatory effects. This can further lead to improved ischemia, reduced swelling, and anti-inflammatory effects. However, serious complications, including hematoma formation and intravascular injection, have been reported [12].

Pereira et al. examined the effect of exercise therapy with or without mirror biofeedback in patients with Bell's palsy, where this approach

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was indicated to effectively enhance functional improvement in these patients [2]. Contrastingly, Teixeira et al. conducted a review assessing the effectiveness of various physical therapy interventions in patients with Bell's palsy. They concluded that insufficient high-quality evidence existed to support the substantial benefits or risks associated with the identified interventions, including acupuncture, electrotherapy, and biofeedback. However, they found low-quality evidence indicating that exercise therapy may positively affect functional improvement in patients with Bell's palsy [13].

Phototherapy has garnered attention because of its potential to enhance the healing process and reduce inflammation in peripheral nerve disorders. Studies have highlighted its capacity to aid in nerve repair, regeneration, and myelination, along with promoting axonal growth, thereby underscoring its therapeutic value [14,15]. Despite advancements in research on the efficacy and mechanisms of phototherapy, numerous uncertainties persist regarding the wavelength, irradiation time, output, and treatment duration of phototherapy . .

Various types of phototherapy treatment devices are used in Japan, including the semiconductor laser (Ga-Al-As semiconductor), which has been commercially available as a light source for low-output laser therapy devices. Presently marketed models include the SoftLaserly JQ-W1, FineLaser EL-1000, and the Semiconductor Laser Therapeutic Device "Sheep." The Softlaser emits at 810 ± 10 nm with adjustable outputs (60, 100, 140, or 180 mW) through its fully independent 2-channel probe system. Another device, the Multi-laser, emits at 830 nm with a fixed output of 60 mW and accommodates five probes, including one pencil probe and four suction probes for thermal stimulation. The Medilaser emits at 830 ± 20 nm, delivering 10 W pulses for 20 ms with a 180 ms interval. The SuperLaser models utilize a Super Iodine lamp (halogen lamp) as the light source, outputting a wavelength range of 600–1600 nm through optical filters. In contrast, the new model, SuperLaser EX, adopts LED as the light source, introducing a new wavelength range of 600–1000 nm [16].

Phototherapy is currently used in various medical specialties, including pain clinics, orthopedics, and dermatology. For instance, in dermatology, the efficacy of low-level laser therapy (LLLT) for pressure ulcers has been reported, and infrared therapy is utilized as an anti-inflammatory and analgesic treatment, with recognized insurance coverage in Japan.

This study aimed to compare clinical outcomes of facial functions among participants receiving LLLT, electrical muscle stimulation, and pharmacological therapies, all combined with facial exercises, using the House–Brackmann Scale (HBS), the Facial Disability Index (FDI), and the Sunnybrook Facial Grading System (SFGS).

This study also evaluated the efficacy of LLLT in improving functional outcomes and overall well-being in patients with Bell's palsy. Furthermore, this study aimed to determine the optimal irradiation time, output, and treatment duration of phototherapy in the orofacial regions, as well as conduct a comparative analysis of the performance and features of phototherapy treatment devices.

2. Methods

This review was conducted in accordance with the guidelines established by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews.

This scoping review was conducted based on the following focus question:

– Is LLLT effective in improving clinical facial function in patients with peripheral facial nerve palsy compared to the control group?

The specific PICO inclusion criteria were determined as follows:

P(Population/problem): Patients with subacute peripheral facial nerve palsy.

I(Interventions): LLLT.

C(Comparison/controls): No intervention, sham laser, exercise therapy, massage, and pharmacotherapy (steroids and antiviral therapy).

O(Outcomes): FDI, HBS, and Sunnybrook method.

2.1. Search strategy

The database search was conducted in PubMed, EMBASE, Web of Science, and Scopus before June 5, 2024, and the selected search terms included ("Laser" OR "phototherapy*" OR "photo therapy") AND ("bell's palsy" OR "bell's palsy" OR "facial neuropathy" OR "facial palsy" OR "Facial palsy"). Additionally, we conducted manual searches of the references cited in the selected studies to identify any additional potentially relevant studies. The initial screening process involved the exclusion of duplicate articles, non-English publications, and articles with titles or abstracts that did not meet the inclusion criteria. Subsequently, secondary screening was conducted to assess the full text and eliminate articles that did not meet the specified criteria.

2.2. Inclusion/exclusion criteria

The inclusion criteria included randomized controlled trials (RCTs) published in any language focusing on phototherapy's effects on Bell's palsy. These trials were required to feature at least one control group receiving a placebo laser, exercise, massage, medication, electrical stimulation (ES), or no intervention. Participants with idiopathic peripheral facial palsy of any sex and age at any stage of Bell's palsy were considered eligible for inclusion, with no specific diagnostic method for Bell's palsy being mandated. Studies using phototherapy with various wavelengths and output power were included, provided that the experimental groups received no additional treatments, such as corticosteroid therapy. Trials comparing phototherapy with exercise and/or massage as control groups were included, whereas those involving laser acupuncture were excluded from the final analysis. This study included outcome measurements of any type.

2.3. Selection process

Three reviewers (KT, KO, and AS) independently evaluated all potentially relevant titles and abstracts to determine their eligibility. After completing the screening of titles and abstracts, three other reviewers (T, TI, and YO) independently assessed the full-text articles corresponding to the selected abstracts. Any disagreements or uncertainties were resolved through a consensus process involving two additional reviewers (KS and NN).

2.4. Data extraction and synthesis

Independent full-text analysis and data extraction were conducted and inputted into an electronic database to elucidate the effectiveness of LLLT in improving functional outcomes and overall health status in patients with Bell's palsy. We recorded key information about each study based on the confirmed literature and types of studies. This included author names, publication year, study design, number of groups, patient age, phase of disease, irradiation method, irradiation time, type of laser, wavelength, frequency (Hz), treatment duration, and performance and features of phototherapy treatment devices (Tables 1–5). Due to the small sample sizes for outcomes such as FDI and SFGS related to LLLT, data synthesis was conducted using this approach. All statistical analyses were performed using EZR version 1.67. Baseline and final assessment data of FDI and SFGS in intervention and control groups were compared in selected studies. Forest plots were provided based on the standardized mean difference (SMD) and 95 % confidence interval (95 % CI) of FDI, as well as SFGS.

Table 1

Author	Study design	Sample size (T/C)	Age (years)	Phase of disease	Intervention/s of LLLTG	Intervention/s of CG	Duration of Tx	Number of total sessions/ frequency (S/W)
Shoman et al. [17]	RCT	45 (15/15/15)	Group(A) 34.66 ± 8.44 Group(B) 32.8 ± 8.09 Group(C) 32.66 ± 8.86	Sub-acute (3 −5 days after on set)	• LLLT + facial massage + facial exs • E.S+ facial massage + facial exs	Medication (corticosteroids and/or antiviral drugs)+ facial massage+ facial exs	6weeks	Group(A) 12/2 Group(B) 12/2 Group(C) Control
Kandakurti et al. [18]	RCT	120 (40/40/40)	NM	Sub-acute (less than 2 weeks)	• LLLT + facial exs • E.S + facial exs	corticosteroids and/or antiviral drugs	6weeks	GroupI 18/3 GroupII 6 ~ 9/3 GroupIII
Ordahan et al. [19]	RCT	46 (23/23)	Mean ±SD,45 ± 22	Sub-acute	LLLT + facial exercise (active assistive, resistive, and PNF exs. In front of mirror)	Facial exs.	6weeks	30/5
Alayat et al. [20]	Double-blind RCT	31 (15/16)	NM	Sub-acute (3 −5 days after on set)	LLLT + facial massage + facial exs (active, active assistive, resistive, PNF and resisted exercise for neck muscles)	Sham laser,Facial massage,Facial exs.	6weeks	18/3
Delgado Castillo et al. [21]	Simple-blind RCT	73 (38/35)	NM	Sub-acute (less than 1 week)	LLLT + facial massage + facial exs	facial massage + facial exs	4weeks	20/5
Macías-Hernández et al. [22]	Double-blind RCT	21 (11/10)	Median LLLTG 38 CG 48	Sub-acute (less than 1 week)	LLLT + facial massage + facial exs (stretching and re-education of facial muscles in front of a mirror)	Sham laser + Superficial heat + Facial massage + Facial exs.	15days	15/7
Javath et al. [23]	A Randomized Clinical Trial	25 (12/13)	NM	Acute (phase; NM)	LLLT + facial massage + facial exs	E.S+facial massage + facial exs	2weeks	12/30

RCT randomized controlled trial,T treatment,C control, NM not mentioned, LLLT low-level laser therapy, LLLTG low-level laser therapy group, CG control group, PNF proprioceptive neuromuscular facilitation, exs exercise, S/W sessions per week, E.S. Electrical Stimulation

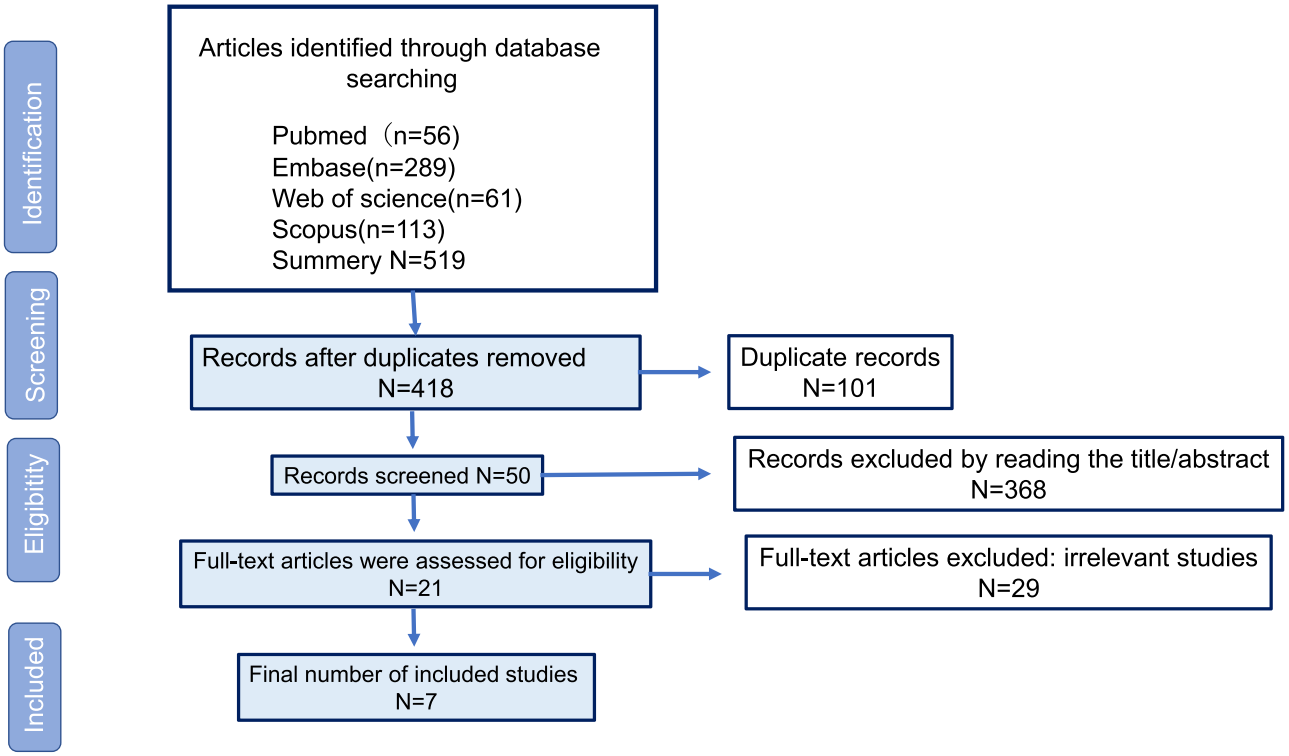

Fig. 1. The flowchart of the literature screening process.

3. Results

3.1. Study selection

The results of the article search and the flowchart illustrating the scoping review process are shown in Fig. 1. Initially, a total of 519 articles were identified through electronic searches. Overall, 418 original articles were screened after removing 101 duplicate articles. Subsequently, based on the inclusion and exclusion criteria, as well as the scoping review question, 21 articles were selected for full-text assessment after reviewing their titles and abstracts. Finally, after reaching a consensus, seven articles were included for further analysis.

3.2. Study characteristics

Table 1 presents the details of the quality assessment. Our final review included five—English [19,20,18,17,23] and two Spanish [21,22] studies. Among them, four studies were designed as controlled RCTs, with one implementing blinding for patients and therapists [20,18,17] and the other employing blinding for patients and assessors [22]. Another group of researchers used simple blinding, although they did not specify who was blinded to the patient allocation [21].

Across the seven selected studies, the LLLT and control groups comprised 154 and 84 patients, respectively. The ES therapy and pharmacotherapy groups consisted of 28 and 40 patients, respectively. Notably, two of the studies incorporated LLLT and control groups [19,22]. Furthermore, one study adopted a parallel RCT design encompassing high-level laser therapy, an LLLT group, and a control group [20]. One study included participants randomly assigned to the following three distinct treatment groups: Groups I, II, and III received LLLT, ES therapy, and steroid/antiviral therapy, respectively [17]. One study employed various interventions, including conventional therapy (CT), magnetic field therapy (MFT) + CT, LLLT + CT, and MFT + LLLT + CT. In our analysis, we categorized the LLLT + CT and CT groups into the intervention and control groups, respectively [21]. In another study, participants were randomly assigned to three groups. Two groups received either LLLT or ES combined with medication, whereas the third group (control) received medication alone [20]. Similarly, in one study, participants were categorized into LLLT or ES (control group), and a randomized clinical trial design was adopted [23].

Across all selected trials, researchers consistently incorporated exercise and massage therapies into their control groups. These established exercise forms and massage therapy were included as integral components of the care methods in the intervention groups. The duration of the treatment sessions varied, ranging from 15 day to 6 weeks, with each patient typically receiving 15–30 sessions as part of their treatment regimen.

3.3. Laser characteristics across the selected studies

All researchers applied laser in a pencil-like manner to the facial nerve roots, with most using a wavelength of 830 nm, one using 850 nm, and one using 795 nm. Table 2 summarizes the laser characteristics of the included studies. The included studies did not report variables such as the emitter number, emitter type, beam delivery system, central wavelength, spectral bandwidth, energy per pulse, polarization, average radiant power, and beam divergence [24].

3.4. Outcome measures and results

Shoman et al. assessed the outcomes by applying facial nerve conduction velocity and the SFGS, evaluating these outcomes before and after treatment [17]. The LLLT group exhibited significant differences compared to the ES group regarding improvements in the amplitude and latency of the facial nerve action potential, signs of nerve regeneration, and SFGS scores.

Alayat et al. used the HBS for assessment, and their results were consistent with the FDI scores [20]. However, they observed an unexpected downward trend over time in the scores of the LLLT and control groups, although improvements were reported. Overall, laser application mitigated the downward trend in the FDI scores in the LLLT group, resulting in a substantial difference between the groups at the 6-week mark.

Castillo et al. evaluated patients using the SFGS at three time points, as follows: baseline, end of treatment (4 weeks), and 12 weeks after intervention [21]. They observed improvements in both groups after laser application.

Macías-Hernández et al. employed four outcome measures at various

Table 2

Study ID	Type of laser	Wavelength (nm)	Frequency (Hz)	Duty cycle (%)	Time of each point (s)/ number of points/total time (s)	Location of point (s)	Set power (mW)/ energy density (J/cm^2)/total energy (J)
Shoman et al. [17]	GaAIAs diode	850	NM	NM	60/8/480	upper branch, middle, lower branch, nerve trunk of facial nerve, orbicularis oris muscle, muscles of the nose, levators of the upper lip, and depressors of the lower lip.	1000/NM/NM
Kandakurti et al. [18]	GaAIAs diode	795(± 5)	1000	NM	4/8/32	Superficial roots of the facial nerve on the affected side	1000/1/4
Ordahan et al. [19]	GaAIAs (infrared) diode	830	1000	NM	120/8/960	Superficial roots of the facial nerve on the affected side	100/10/80
Alayat et al. [20]	GaAs (infrared)	830	1000	80	125/8/1000	Superficial roots of the facial nerve on the affected side	100/NM/80
Delgado Castillo et al. [21]	NM	670	NM, but mentioned laser was pulsatile	NM	Starting with 30 s and increase 15 s every 5 sessions until reach to 1 m/NM/NM	Through the course of facial nerve with 1.5-cm space between two points and extra points and extra point at nerve exit locale	40/14/NM
Macías-Hernández et al. [22]	GaA1As	830	NM	NM	NM/NM/NM	In the emergence of facial nerve	30/20/NM
Javath et al. [23]	NM	830	1000	80	5 × 60/8/2400	8 points:oculi,levator labii superioris alaeque nasi, levator labii superioris,levator anguli oris, risorius, orbicularis oris, depressor anguli oris, depressor labii inferioris, and levator menti.	NM/10/80

GaAlAs gallium-aluminum-arsenide, GA gallium-arsenide, nm nanometer, NM not mentioned, S second, J joule, mW milliwatt

time points, as follows: baseline, end of treatment sessions (15 d), and 30 and 60 d after interventions [22]. They observed improvements in muscle function and perception after 15 LLLT sessions over 15 d, similar to those in the control group. However, this study did not report the statistical results for the within-group analysis between baseline and the end of treatment. Additionally, the differences between the groups were insignificant except for improved perception in the LLLT group after 60 d. Furthermore, all patients in both groups exhibited normal palpebral occlusion without epiphora or dysgeusia 30 d after the interventions.

Kandakurti et al. evaluated functional recovery using the FDI and HBS at baseline and 3, 6, and 12 weeks after the treatment [18]. They administered LLLT, ES, and corticosteroid/antiviral therapy and reported that the combination of LLLT and facial exercise therapy facilitated complete functional recovery of the face. Table 3 summarizes the results of all included studies.

3.5. Synthesis of results

Research on the efficacy of LLLT for facial nerve paralysis was reported in seven studies [19,20,18,17,23,21,22], and the detailed information is presented in Table 3. However, in two of these studies, the values of standard deviation were not reported, preventing the pooling of data. Consequently, a meta-analysis for HBS could not be conducted. The forest plots for Sunnybrook (A) and FDI (B) compared between the LLLT and control groups are presented in Fig. 2. In three studies [17,23,21], LLLT conducted with wavelengths ranging from 630 to 850 nm and frequencies of 1000 Hz for 2–6 weeks revealed improved facial nerve function when pooling data from the SFGS. These studies were pooled using a random-effects model (I^2 = 93%) for Sunnybrook, and a significantly higher Sunnybrook rate was found for the LLLT group than the control group (Fig. 2 A, MD = 17.42, 95% CI: 4.00–30.84, p = 0.011). In two studies [19,23], LLLT conducted with a wavelength of 830 nm and a frequency of 1000 Hz for 2–6 weeks revealed no significant difference in facial nerve function compared to the control group when pooling data from the FDI. These studies were pooled using a random-effects model (I^2 = 94%) for FDI, and no significant difference was found between the two groups (Fig. 2B, MD = 12.16, 95% CI: −0.60 to 24.92, p = 0.061).

3.6. Comparison of main performance and features of phototherapy treatment devices

We have summarized the main performance and characteristics of phototherapy treatment devices in Tables 4 and 5. For each type of phototherapy treatment device, details including Light Source, Wavelength, Rated Output, Number of Channels Simultaneously Illuminable, Irradiation Output Settings, Treatment Timer Settings, Irradiation Mode Settings, Irradiation Aperture, Power Consumption, and External Dimensions have been provided. The specifications of the LLLT devices are as follows: The Supervisor EX has a wavelength range of 600–1000 nm with a rated output of 5000 mW and treatment timer settings from 1 to 10 min. The Supervisor PX Type1 and Type2 both have a wavelength range of 600–1600 nm. Type1 has a rated output of 10,000 mW, whereas Type2 has a rated output of 5000 mW. Both have treatment timer settings from 1 to 10 min. The Supervisor HA-2200 TP1 and TP2 also have a wavelength range of 600–1600 nm with a rated output of 2200 mW and treatment timer settings from 1 to 20 min[25].

The Alpha Beam ALB-P1 and ALB-200H have a wavelength range of 700–1600 nm with a rated output of 2350 mW. Both have treatment timer settings ranging from 10 s to 10 min

The SoftLayer JQ-W1 operates at a wavelength of 810 nm with a rated output of 180 mW and treatment timer settings from 10 to 60 s. The Fine Laser EL-1000 has a wavelength of 830 ± 20 nm with a rated output of 10,000 mW± 20% and treatment timer settings of 5, 10, 15, and 30 s. Finally, the Semiconductor Laser Therapeutic Device “Sheep” operates at a wavelength of 830 nm with a rated output of 10,000 mW

Table 3

Study ID	Outcome measurements	Assessment times	Summary of results
Shoman et al. [17]	Sunnybrook facial grading system	Pretreatment and posttreatment	Group(A)(LLLTG): SI at posttreatment than pretereatment Group(B)(E.S): SI at posttreatment than pretereatment Group(C)(CG): SI at posttreatment than pretereatment BGA: SI at Group(A) than Group(B) and Group(C)
Kandakurti et al. [18]	FDI (PFDI,SFDI) HBS	Before, 3, 6, and 12 weeks	LLLT : SI at GroupI than another groups Functional recovery is assessed at baseline, 3, 6, and 12 weeks using the Facial Disability Index and House-Brackmann Scale.
Ordahan et al. [19]	FDI (PFDI,SFDI)	Before, 3 and 6 weeks	LLLTG: SI at 3 and 6 weeks CG: No improvement (exception BTW baseline and 6 weeks) Higher FDI at 3 and 6 weeks in LLLT
Alayat et al. [20]	FDI (PFDI,SFDI) HBS	Before, 3 weeks, 6 weeks	LLLTG: SI of both scores at 3 and 6 weeks with greatest improvement at 6 weeks CG: ↑FDI and HBS after 3 and 6 weeks Higher FDI 3 and 6 weeks in the LLLT. Higher HBS 6 weeks in the LLLT (No effect on HBS after 3 weeks of irradiation)
Delgado Castillo et al. [21]	Sunnybrook facial grading system	Before, 4 weeks, 12 weeks	LLLT: SI at 4 and 12 weeks with greatest improvement at 12 weeks. CG: SI at 4 and 12 weeks with greatest improvement at 12 weeks. BGA: No significant difference between groups at 4 and 12 weeks.
Macías-Hernández et al. [22]	• MMT of 18 facial muscles • Presence of epiphora and dysgeusia • Palpebral occlusion capacity (mm) • % of improvement (self-assessment)	Before, 15, 30, and 60 days	LLLT: All outcomes improved at 60 days than baseline. CG: All outcomes improved at 60 days than baseline. BGA: NS for all outcome measures BTW groups (exception of improvement perception for the LLLT after 60 days). NS on paipebral occultation and no difference on number of patients with epiphora and dysgeusia between the groups after 15 days. All patients were fine 30 days following interventions.
Javath et al. [23]	• FDI (PFDI, SFDI) • Sunnybrook	Before, 12 weeks	Significant improvement observed in SFGS and FDI scores within both

(continued on next page)

Table 3 (*continued*)

Study ID	Outcome measurements	Assessment times	Summary of results
	facial grading system		LLLT and ES groups. No significant difference detected in SFGS and FDI scores between the LLLT and ES groups. Both LLLT and ES show comparable effectiveness in enhancing facial symmetry and function in acute Bell's palsy.

FDI facial disability index, PFDI physical facial disability index, SFDI social facial disability index, HBS House-Brackmann scale, MMT manual muscle testing, mm millimeter, VAS visual analogue scale, LLLTG low-level laser therapy group, CG control group, BGA between group analysis, SI significant improvement, E.S. Electrical Stimulation

and treatment timer settings of 2.5 min or 5 min

4. Discussion

This scoping review aimed to evaluate phototherapy's effectiveness in the recovery of Bell's palsy. Seven studies met the selection criteria and included 306 patients with subacute Bell's palsy [19,20,18,17,23,21,22]. Two studies administered a Gallium Aluminum Arsenide (GaAlAs) laser (wavelength, 830 nm), whereas one study used a GaAlAs laser (wavelength, 850 nm) for 6 weeks, reporting LLLT's effects. Similarly, Kandakurti et al. reported the effectiveness of GaAlAs laser irradiation for 6 weeks combined with facial exercise therapy in patients with moderate-to-severe Bell's palsy [18]. Contrastingly, Castillo et al. found no evidence of effectiveness after applying LLLT (wavelength: 670 nm) for 4 weeks in patients with Bell's palsy [21].

Based on the latest findings, using 830 nm LLLT with a power output of 100 mW and a duration of 120 s, targeting eight specific points along the facial branches of the affected area, administered over 6 weeks, may have a beneficial effect on the functional outcomes of patients with Bell's palsy during the sub-acute stage.

Furthermore, Shomana et al. recommended using 850 nm LLLT continuously for 6 weeks, emphasizing a laser probe power density of 1 W/cm^2 [17]. This therapy was applied for 8 min at each of the eight designated points for a total of 1 min per point. Contrastingly, Kandakurti et al. used an LP-1000 laser device with a 795 nm (± 5 nm) wavelength and 1 W output [18]. Their protocol involved applying laser energy to eight specific points along the superficial neural pathways of the facial nerve. At each point, an average energy density of 1 J/cm^2 per second was delivered for 4 s, resulting in a total energy delivery of 4 J per point.

Based on the results of this meta-analysis, LLLT was found to be more effective than the control group when using the SFGS as an outcome (MD = 17.42, 95% CI: 4.00–30.84, p = 0.011). However, when using the FDI, no significant difference was observed in effectiveness compared to the control group (MD = 12.16, 95% CI: −0.60 to 24.92, p = 0.061). These results are based on a small number of studies, and some meta-analyses showed high heterogeneity; therefore, the results should be cautiously interpreted.

SGB is a form of sympathetic block frequently performed to alleviate vascular insufficiency and pain in the face, neck, and upper limbs [26]. Fearnley et al. contended that a sympathetic blockade should only be pursued if it demonstrates clear and remarkable benefits [27]. SGB exerted its therapeutic effect by inducing a considerable increase in blood flow through the common carotid artery.

However, complications associated with SGB include medication-related or systemic side effects, procedure-related or local side effects such as nerve injury or bleeding, and potentially serious outcomes such as airway obstruction from a hematoma or quadriplegia due to cervical epidural abscess or discitis. This underscores the importance of proper technique and vigilant patient monitoring during the procedure [12].

Murakami et al. conducted a comprehensive clinical trial to evaluate and compare the efficacy of three distinct interventions— SGB, infrared diode laser therapy (830 nm), and a combined approach—in patients with subacute Bell's palsy. Notably, their meticulous analysis illuminated intriguing findings, revealing that individuals treated with LLLT exhibited markedly increased rates of initial recuperation and marginally superior final paralysis scores compared to their counterparts subjected to alternative therapeutic modalities [28]. These compelling outcomes underscore LLLT's potential as a promising avenue for managing subacute Bell's palsy and advocate for its further exploration and integration into the clinical armamentarium, thereby potentially enriching the therapeutic strategies for this debilitating condition.

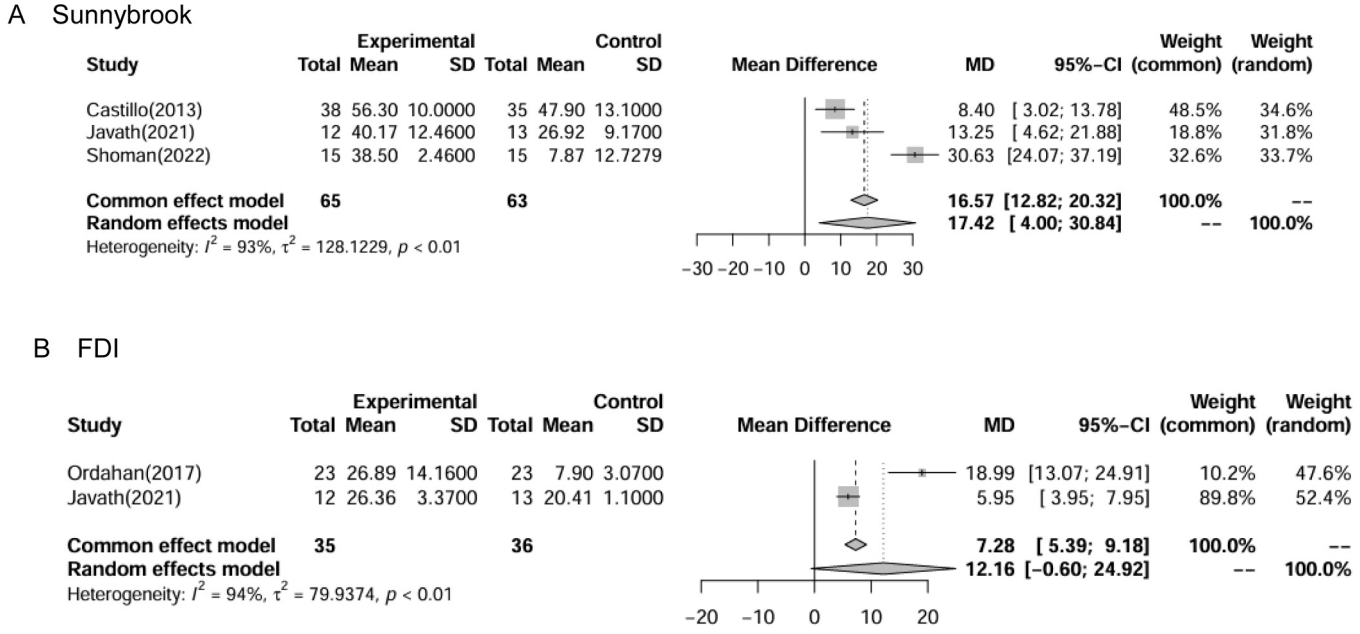

Fig. 2.

Table 4
Comparison of Main Performance and Features of Phototherapy treatment device (Supervisor).

Type	Supervisor EX	Supervisor PX Type1	Supervisor PX Type2	Supervisor HA-2200 TP1	Supervisor HA-2200 TP2
Light Source	High-precision LED	Super iodine lamp	Super iodine lamp	Super iodine lamp	Super iodine lamp
Wavelength	600 ~ 1000 nm	600 nm ~ 1600 nm	600 nm ~ 1600 nm	600 nm ~ 1600 nm	600 nm ~ 1600 nm
Rated Output	5000 mW: When using C, CH, and Light Pad Probe	10000 mW: When using B1 type unit	5000 mW: When using B2 type unit	2200 mW: When using B type unit	2200 mW: When using B Type Unit
Number of Channels Simultaneously Illuminable	2	1	2	1	2
Irradiation Output Settings	10 ~ 100%	10 ~ 100%	10% ~ 100%	10% ~ 100%	10% ~ 100%
Treatment Timer Settings	1 ~ 10 min	1 ~ 10 min	1 ~ 10 min	1 ~ 20 min	1 ~ 20 min
Irradiation Mode Settings	Hand - Fixed	Hand - Fixed	Hand - Fixed	Continuous Irradiation Cycle Irradiation P Mix Irradiation T Mix Irradiation Safety Mode Irradiation	Continuous Irradiation Cycle Irradiation P Mix Irradiation T Mix Irradiation Safety Mode Irradiation
Irradiation Aperture	16㎠: C・CH Probe 0.38㎠: SG Probe 0.64㎠: B Probe 51㎠: Light Pad	0.79㎠: B1 Type Unit 34.2㎠: C1 Type Unit 0.50㎠: SG1 Type Unit 7.07㎠: Y1 Type Unit 0.38㎠: PS1 Unit	0.64㎠: B2 Type Unit 11.3㎠: C2 Type Unit 0.50㎠: SG2 Type Unit 3.8㎠: Y2 Type Unit 0.38㎠: PS2 Unit	φ10mm: B Type Unit φ80mm: C Type Unit φ55mm: D Type Unit φ7mm: SG Type Unit	φ10mm: B Type Unit φ80mm: C Type Unit φ55mm: D Type Unit φ7mm: SG Type Unit
Power Consumption	207 VA	220 VA	220 VA	220 VA	440 VA
External Dimensions	464(W)× 464(D)× 1368 (H)mm	390(W)× 445(D)× 1400 (H)mm: Including the Arm	390(W)× 445(D)× 1400 (H)mm: Including the Arm	521(W)× 445(D)× 1330 (H)mm: Including the Arm	560(W)× 552(D)× 1430 (H)mm: Including the Arm

Table 5
Comparison of Main Performance and Features of Phototherapy treatment device (others) .

Type	AlphaBeam ALB-P1	AlphaBeam ALB-200H	SoftLaserly JQ-W1	FineLaser EL-1000	Semiconductor Laser Therapeutic Device "Sheep"
Light Source	Halogen Lamp	Halogen Lamp	Semiconductor Laser	Semiconductor Laser	Semiconductor Laser
Wavelength	700 nm ~ 1600 nm	700 nm ~ 1600 nm	810 nm	830 nm ± 20 nm	830 nm
Rated Output	2350 mW: When using the standard attachment	2350 mW: When using the standard attachment	180 mW	10000 mW± 20%	10000 mW
Number of Channels Simultaneously Illuminable	1	2	1	1	1
Irradiation Output Settings	10 ~ 100%	10 ~ 100%	60/100/140/ 180 mW	unknown	unknown
Treatment Timer Settings	10 s to 10 min	10 s to 10 min	10 ~ 60 s	5, 10, 15, 30 s	2.5 min / 5 min
Irradiation Mode Settings	Continuous Mode Intermittent Mode Rhythm Mode	Continuous Mode Intermittent Mode Rhythm Mode Soft Irradiation	Hand	Hand - Fixed	Hand - Fixed
Irradiation Aperture	φ5mm: Standard Attachment Unknown: Small Attachment Unknown: Wide Touch Attachment Unknown: L-type Attachment	φ5mm: Standard Type Attachment Unknown: Small Type Attachment Unknown: Wide Touch Attachment Unknown: L-type Attachment	0.35㎠	1.5㎠	1.96㎠
Power Consumption	250 VA	380 VA	40 VA	150 VA+ 10%以下	34 VA
External Dimensions	330(W)× 355(D)× 122(H)mm: Body Only 489(W)× 436(D)× 842(H)mm: When placed on stand, excluding arm	635(W)× 330(D)× 700 (H)mm: Excluding Arm	190(W)× 220(D)× 80(H)mm	430 (W) × 340 (D) × 157 (H) mm	W140 ×D230 ×H210㎜

Notably, LLLT may offer particular advantages for patients with Bell's palsy who also have comorbidities such as diabetes. In these cases, complications, including hematoma, following SGB are a substantial concern. This emphasizes the preference for LLLT, as it presents a safer option with potentially fewer adverse effects for this specific patient population. The heightened risks associated with SGB in patients with diabetes include compromised wound healing and increased infection susceptibility [29]. LLLT has emerged as a highly favorable therapeutic option that is under robust consideration in clinical practice. Acknowledging the potential benefits of LLLT in such patients underscores the necessity of tailoring treatment approaches to individual patient profiles and medical histories, thereby optimizing therapeutic outcomes while mitigating potential risks.

Based on clinical research, the most commonly used wavelength for treating Bell's palsy is between 830 nm and 850 nm. These wavelengths effectively penetrate deeply into tissues, such as neural tissue, easily reaching the deeper layers of the skin. The irradiation time typically ranges from a few minutes to 20 min. Prolonged exposure beyond this range may risk overheating of the skin. The duration of treatment varies depending on the severity of the patient's symptoms and the progression of their condition. LLLT treatments are administered over several weeks to 6 months. The Laser series of equipment, utilizing semiconductor laser diodes made from materials such as GaAlAs, primarily between 810 nm and 830 nm of near-infrared light, can be considered the most suitable for treating Bell's palsy. The laser light used in LLLT has low absorption wavelengths (790–930 nm) for water and hemoglobin,

enabling it to penetrate deeply into facial tissues [30].

As another form of phototherapy, the SuperLaser EX utilizes an LED light source, significantly enhancing energy efficiency compared to the conventional SuperIodine lamp. The light source of SuperLaser EX halogen light spans the wavelength range of 600–1600 nm, providing excellent penetration rates for bodily water, oxidized hemoglobin, and melanin pigments, which are crucial for therapeutic effects. However, SuperLaser EX operates within the wavelength range of 600–1000 nm, providing 100% transmission rates to bodily water, oxidized hemoglobin, and melanin pigments, making it an excellent therapeutic light source. The AlphaBeam series utilizes halogen lamps as light sources with wavelengths ranging from 700 nm to 1600 nm.

The mechanism of action of phototherapy includes reported effects, such as improvement and increase in blood flow, anti-inflammatory properties, promotion of wound healing, and stabilization of the autonomic nervous system [31]. The main mechanism of action is attributed to the broad spectrum of wavelengths, which ensures effective penetration into deep tissues, such as the upper branch, middle branch, lower branch, and nerve trunk of the facial nerve, leading to improvement in blood flow and metabolism at affected sites, thereby facilitating tissue repair and regeneration. Additionally, when irradiated near the stellate ganglion, it exhibits effects similar to sympathetic nerve blocks, suppressing sympathetic nervous activity and leading to reported effects of peripheral tissue vasodilation and increased skin temperature in the head and neck region [32].

5. Conclusion

LLLT shows promise as a management option for Bell's palsy, potentially offering advantages over other treatments, particularly in patients with comorbidities such as diabetes. Its efficacy and safety make it a valuable addition to the armamentarium of therapeutic interventions for this condition. Additionally, the most effective conditions for LLLT involve wavelengths between 830 nm and 850 nm, with irradiation times ranging from a few minutes to 20 min. Furthermore, the LLLT devices currently in use are effective and safe, underscoring their potential as valuable tools in managing various conditions.

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Conflict of interests

All authors declare that they have no conflict of interests in regard to this work.

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