Photobiomodulation in Temporomandibular Disorders

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Abstract

Objective: This systematic review aimed to comprehensively review all available documents regarding photobiomodulation therapy (PBMT) application in temporomandibular disorder (TMD) patients and to suggest an evidence-based protocol for therapeutic PBM administration for these patients.

Background data: The existence of temporomandibular joint and/or pain and dysfunction in masticatory muscles is characterized in TMDs. PBMT is, due to its impact on biological processes, especially inflammation, considered as an adjuvant treatment modality in TMD cases.

Materials and methods: All original articles related to PBMT for TMDs in EMBASE, MEDLINE (NCBI PubMed and PMC), Cochrane library, Scopus, Web of Science, and Google Scholar were reviewed until December 2018.

Results: The energy density ranging from 0.75 to 112.5 J/cm² with 0.9–500 mW power was found to be a window protocol for light application. The best results for pain relief and mandibular movement enhancement were reported after application of GaAlAs diode laser, 800–900 nm, 100–500 mW, and <10 J/cm², twice a week for 30 days on trigger points. The session of light applications varied from 1 to 20.

Conclusions: Although most articles showed that PBMT is effective in reducing pain and contributed to functional enhancement in TMD patients, the heterogenic parameters that have been reported in various studies made the standardization of PBMT complicated. However, such evidence-based consensus can be beneficial for both future research and for clinical applications.

Keywords: photobiomodulation, low-level laser therapy, temporomandibular joint, temporomandibular disorder

Introduction

CLINICAL DISORDERS OF THE TEMPOROMANDIBULAR JOINT (TMJ) with or without masticatory muscles' disorder encompass a wide range of temporomandibular disorders (TMDs).¹ Acute or chronic pain, tinnitus, loss of mandibular function, and finally degeneration of tissues are the main signs and symptoms related to TMDs.^{2–4} These issues can be more problematic for patients, influencing quality of life and mental health,⁵ through sleep problems,⁶ increased anxiety and stress, and even causing depression.⁷ The prevalence of TMDs is different between countries (ranges between 21.5% and 50.5%) and genders (more common among males).^{8–10} However, its pathophysiology is still not totally understood. Previous studies have shown that TMD is multi-factorial, encompasses biomechanical, biological and physiological, psychological, and neuromuscular factors.¹¹ Therefore,

for treating TMDs, various approaches including manual therapy,¹² ultrasound,¹³ transcutaneous nerve stimulation,¹⁴ electrotherapy,¹⁵ and photobiomodulation therapy (PBMT) have been applied. The main purpose of all these therapeutic approaches is to decrease symptom intensity, thereby enhancing the function of the masticatory muscles, TMJ, and adjacent anatomical structures.^{16–18} Among nonsurgical treatment modalities, PBMT has increased in interest during the past few years, conceivably due to its ease of application in conjunction with growing scientific evidence regarding its positive impacts on pain alleviation.¹⁹

PBMT is a treatment method that commonly consists of noncollimated, coherent, and monochromatic beams of low intensities of laser light. However, during the past decade, noncoherent light sources such as light-emitting diodes (LEDs) have frequently been applied. LEDs do not need the safety considerations like lasers and can be easily administrated

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over a large area of tissues and even at home.²⁰ In this review, we searched for all types of PBM administrations but only found one relevant study using LED.²¹ Further, we found one clinical study utilizing a combination of laser and LEDs.²²

PBM as a nonthermal light can cause metabolic alterations in cells and tissues such as inducing cellular respiration, enhancing vascularization, and fibroblastic differentiation^{23,24} that are important for its therapeutic impacts. Chow and Armati demonstrated that high doses of laser light, in contrast to low stimulatory doses, disrupt neuronal physiology, and the cellular skeleton, and affecting axonal flow that was reversible and did not cause any permanent nerve damage.²⁵ The exact mechanism of pain relief through PBMT is not still clear and there is no global consensus regarding “laser-assisted analgesia.” However, there is some evidence regarding its anti-inflammatory and pain relief impacts in dysfunctional or painful muscles and joints.

One theory suggests the analgesic effect to be a consequence of the reduction of levels of prostaglandin E,^{26–28} which is one of the most important proinflammatory mediators. Moreover, PBM intensifies the synthesis of adenosine triphosphate (ATP), cyclic adenosine monophosphate, and reactive oxygen species.²⁹ PBM further increases the electrons’ availability in the catalytic center of cyclooxygenase (COX).^{30–32} Several systematic reviews and meta-analyses have analyzed the effect of PBMT in musculoskeletal disorders, but only two partially focused on TMDs.^{33,34} These articles analyzed the effective dosage and power density, related to specific anatomical factors, to assess the reduction of symptoms.³³

The current systematic review aimed to comprehensively review all available documents regarding PBM application in TMD patients and to suggest a preliminary evidence-based protocol for PBM administration for these patients.

Methods

Protocol and eligibility criteria

This review is organized and followed PRISMA guidelines.³⁵

Types of studies. All *clinical trials*, which administered PBM for TMJ dysfunction as a therapeutic approach and reported the results of PBM individual application, were included. *In vivo* and *in vitro* studies, systematic and literature reviews, letter to editors, and theses were omitted.

Types of participants. Humans were the only accepted participants in the included studies, and any type of animal models (such as rats and primates) and high-level laser therapy (such as CO₂ laser) were excluded.

Types of interventions. Studies investigating PBMT on TMJ dysfunction including acute/chronic pain, loss of movement, and masticatory malfunction were included.

Types of outcome measures. The included studies were categorized based on the complication types. These complications include pain, mandibular loss of function, and muscular tenderness, which have been evaluated by different tests, such as visual analog scale,³⁶ Beck anxiety invento-

ry,³⁷ colorimetric capsule method, craniomandibular index, and fibromyalgia impact questionnaire.

Information sources

EMBASE, MEDLINE (NCBI PubMed and PMC), Cochrane library, Scopus, Web of Science, and Google Scholar were the information sources. Moreover, a hand search was performed specifically in the following journals: *Lasers in Medical Science*, *Journal of Photochemistry & Photobiology B*, *Photomedicine Laser Surgery*, *Tissue Engineering: Part A*, *Lasers in Surgery and Medicine*, and *Journal of Dental Research*.

Search strategy

An electronic search was conducted in PubMed from January 1990 to December 2018, limited to English language publications. Published articles on photobiomodulation in TMD were found using the following keywords alone or ensemble: (“Laser Therapy”[Mesh] or “Low-Level light Therapy”[Mesh] or “Laser Phototherapy”[Mesh] or “Photobiomodulation Therapy”[Mesh] or “Low-Level Laser Irradiation”[Mesh]) and (“temporomandibular joint disorder”[Mesh] or “craniomandibular disorder”[Mesh] or “temporomandibular joint dysfunction syndrome”[Mesh] or “TMJ pain” or “TMD”). In addition, manual search of the articles in the selected journals was performed.

Study selection and data extraction

Two independent experienced reviewers analyzed all retrieved articles based on their keywords, titles, and abstracts. After initial assessment, included studies were analyzed based on their full text, and in the case of disagreement between two reviewers, a third expert person involved to resolve it by discussion. After all, we reviewed all full texts in which all the authors participated and confirmed. All steps were performed based on the PRISMA statement. Data were summarized according to the following: (1) author and year of publication; (2) light properties including light type, wavelength, power, and energy density; (3) sample size; (4) treatment protocol and location of laser application; (5) method of evaluation; (6) follow-up period; and (7) outcome of study.

To evaluate the quality of the included studies, the Jadad scale was used as previously described by Genev et al.³⁸ The articles with 3 or more points were categorized as good quality studies and articles with less than 3 points were labeled as poor quality studies.

Results and Discussion

Selection

The PRISMA flow diagram of our search strategy in this study is illustrated in Fig. 1. Thirty-five articles were retrieved from Medline and 47 articles from other databases and 1 study from hand search. Two independent reviewers initially found 82 articles with screening, and 28 studies were excluded due to duplication and unrelated keywords according to our review design. After exclusion of nonrelevant articles, the full texts of 47 studies were evaluated. Within these studies, six of them were excluded since they

FIG. 1. Study design flowchart based on the PRISMA statement.

were review studies.^{2,39–43} One of the excluded studies was a case report⁴⁴ and another study did not report light properties.⁴⁵ Finally, 39 studies were selected and analyzed in this systematic review. All studies are summarized in Table 1.

Indications of PBM for TMDs

The findings of the included articles suggested that PBM was an effective way of decreasing pain as compared with placebo in TMD patients (29 studies out of 39). Moreover, PBM improved mandibular movements in eight studies^{46–54} and reduced patients' anxiety in two studies.^{46,48} Collecting information of these heterogeneous clinical trials showed beneficial impacts of PBM on reducing pain at the short-term follow-up (10 days to 4 weeks) both in the visual analog scale³⁶ and in the anxiety questionnaire.^{46,47,55–57} Among these studies, GaAlAs diode at 780 nm wavelength and 50 mW power showed the most frequent nonsignificant effects.^{58,59} Functionality of TMJ was assessed in terms of maximum opening, electromyography, geometric mean diameter, colorimetric capsule method, and craniomandibular index, indicating that the total effect favored PBM in comparison with placebo.^{46–54} Moreover, four studies indicated pressure pain threshold improved by PBM,^{49,60–62} but De Carli et al.⁶³ showed that PBM+piroxicam as well as piroxicam alone was as effective, but piroxicam was better for pain at 30 days. This fact leads us to the suggestion that the administration of PBM has to been seen as an adjuvant therapeutic approach for TMD treatment^{42,52} due to its analgesic, anti-inflammatory, and regenerative effects with high patients' satisfaction and minimum side effects.^{34,41,60,62–64} Most of the articles' Jadad scale numbers were 5 (highest score), and only four of them got 3 points due to the lack of blinding or blinding method,^{54,59,48} and randomization method,⁶⁵ showing that all included articles had good quality.

Given the lack of robust evidence and also the heterogeneity of existing data regarding PBMT for TMDs, previous systematic reviews could not reach a conclusive protocol.^{2,39,66,67} In the current review, we collect all existing clinical trials about the analgesic impact of PBMT that are inconsistent with previously reported reviews by Xu et al.⁶⁶ and Chang et al.² In addition, findings about the mandibular motion were in accordance with Chen et al.⁴² and Xu et al.⁶⁶ Our systematic review, in comparison with

the aforementioned reviews, covers a larger number of investigations and includes the most recent articles. Pain is the most common chief complaint of TMDs and the most frequent PBMT indication. This symptom can occur at any stage of TMDs and it has been shown that pain relief can ameliorate chewing and functionality of jaws and masticatory muscles.^{42,49,65,68} Thus, our first aim was to assess the impact of PBMT on pain alteration. Drawing a precise conclusion is difficult due to the diversity of the physical parameters of PBMT and various dosage application. For instance, there are four studies comparing low dosage application with high dosage.^{51,60,69,70} Only one of them⁶⁰ demonstrated better results in high dosage application, whereas the others showed no difference. In this review, focus has been on dosage/fluence/energy density (J/cm^2). Another important parameter in PBMT is the energy per point, which is less frequently reported but can in many cases be calculated. Other parameters such as time of irradiation, spot size, and beam configuration will influence the result and all these parameters need to be attended to in future research. For clinical studies, the World Association for Laser Therapy⁷¹ recommends the use of "energy dose" (J) and reporting in J/cm^2 should also be confined to *in vitro* and *in vivo* investigations.⁷²

PBM physical properties

The physical properties of the irradiation such as wavelength, power, and energy density were different within the included studies in addition to a varying magnitude of energy applied on the target site. For instance, in the study by Carrasco et al.,⁶⁹ three different dosages were used: 25, 60, and 105 J/cm^2 , but the findings were the same for all protocols. After analyzing the most frequent and successful protocols for PBM pain relief and movement enhancement, we suggest the best window of parameters for PBMT of TMD patients in Table 2. Fourteen studies reported how the actual energy output of the laser has been verified.^{22,46,48–50,53,57,59,63,73–77} Authors are sometimes seemingly reporting properties according to manufacturer specification rather than performing independent measuring. We have summarized their calculated energy density, which was between 4 and 112.5 J/cm^2 as given in Table 1.

TABLE 1. PHYSICAL CHARACTERISTICS, STUDY DESIGN, AND MAIN OUTCOMES OF LOW-LEVEL LASER THERAPY (PHOTOBIO-MODULATION) ON TEMPOROMANDIBULAR JOINT DISORDER IN INCLUDED CLINICAL TRIALS

Author (ref.)	Laser properties					Sample size (n)	Treatment protocol and location	Method of evaluation	Follow-up period	Outcome	Jadad score
	Type	Wavelength (nm)	Power (mW)	Energy density (J/cm^2)							
Brochado et al. ⁴⁶	GaAlAs diode	808	100	13.3		51	Three times a week, TMJ and MM	VAS, BAI	4 Weeks	PBM vs. placebo ↓ pain ($p \leq 0.05$), ↑ mandibular function ($p < 0.001$), ↓ patients' anxiety ($p \leq 0.05$)	5
Magri et al. ⁵⁵	GaAlAs diode	780	Masseter and anterior temporal: 20 TMJ: 30	Masseter and anterior temporal: 5 TMJ: 7.5		64	Three times a week, TMJ and MM	VAS, BAI, salivary cortisol	30 Days	PBM vs. placebo ↓ pain ($p < 0.05$)	5
Magri et al. ⁸²	GaAlAs diode	780	Masseter and anterior temporal: 20 TMJ: 30	Masseter and anterior temporal: 5 TMJ: 7.5		91	Three times a week, TMJ and MM	VAS, PPT, SF-MPQ	4 Weeks	PBM vs. placebo NS	5
Seifi et al. ⁴⁷	GaAlAs diode	810	NM	NM		40	Four times a week, TMJ and MM	VAS, MO	4 Weeks	PBM vs. placebo ↓ pain ($p < 0.001$), ↑ mandibular function ($p = 0.002$)	5
Shobha et al. ⁵⁶	GaAlAs diode	810	100	6		40	Four times a week, TMJ and MM	VAS	4 Weeks	PBM vs. placebo ↓ pain ($p < 0.001$)	5
Demirkol et al. ⁴	Nd:YAG, GaAlAs diode	1064, 810	250	8		31	Five times a week, TMJ and MM	VAS	4 Weeks	ND:YAG vs. 810 nm diode NS ($p > 0.05$)	5
Cavalcanti et al. ⁵⁷	GaAlAs diode	780	70	35		60	Five times a week, TMJ and MM	Presence or absence of pain	4 Weeks	PBM vs. placebo ↓ pain ($p < 0.05$)	3
Machado et al. ⁵⁸	GaAlAs diode	780	60	60		48	One time a week in first 60 days and biweekly next 12 weeks, TMJ and MM	ProTMD multi—part II questionnaire, VAS, OMES	3 Months	PBM vs. placebo NS ($p > 0.05$)	5
de Godoy et al. ⁵⁹	GaAlAs diode	780	50	33.5		9	Two times a week, TMJ	VAS, MO		PBM vs. placebo NS ($p > 0.05$)	5
da Silva et al. ⁵¹	GaAs/GaAlAs diodes	905, 650, 875	0.9, 15, 17.5	0.75, 5, 5.83		60	Two times a week, 11 locations with 9 diodes.	VAS, McPQ, FIQ	10 Weeks	Combination of PBM and EXT ↓ pain ($p < 0.05$)	5

(continued)

TABLE 1. (CONTINUED)

Author (ref.)	Laser properties				Sample size (n)	Treatment protocol and location	Method of evaluation	Follow-up period	Outcome	Jadad score
	Type	Wavelength (nm)	Power (mW)	Energy density (J/cm^2)						
Rodrigues et al. ⁴⁸	GaAlAs diode	780	10	5	50	Two times a week, TMJ and MM	VAS, MO	4 Weeks	PBM vs. placebo ↓ pain ($p=0.02$), ↑ mandibular function ($p=0.038$), ↓ patients' anxiety ($p=0.0167$)	3
Demirkol et al. ⁷⁸	Nd:YAG	1064	250	8	30	Once a day, MM	VAS	10 Days	PBM vs. occlusal splint	5
Sancakli et al. ⁶⁰	GaAlAs diode	820	300	3	30	Three times a week, TMJ and MM	VAS, PPT	4 Weeks	↓ pain ($p<0.05$) PBM vs. placebo ↓ pain ($p<0.05$), ↑ mandibular function ($p<0.05$)	5
de Moraes Maia et al. ⁴⁹	GaAlAs diode	808	100	70	21	Two times a week, 5 points on TMJ and MM	VAS, PPT, GMD	4 Weeks	PBM vs. placebo ↑ mandibular function ($p<0.01$)	5
Ahrari et al. ⁵⁰	GaAlAs diode	810	50	3.4	20	Three times a week, 4 points on TMJ and MM	VAS	4 Weeks	PBM vs. placebo ↓ pain ($p<0.05$), ↑ mandibular function ($p<0.05$)	5
Herpich et al. ²²	GaAs/GaAlAs diodes	905, 640, 875	0.9, 15, 17.5	NM	60	Once a day, 5 points on MM	EMG, VAS	48 Hours	Combined PBMs vs. placebo ↓ pain ($p<0.001$)	5
Madani et al. ⁷⁴	GaAlAs diode	810	50	3.4	20	Three times a week, TMJ and MM	MO, VAS	4 Weeks	PBM vs. placebo NS ($p>0.05$)	5
Pereira et al. ⁷⁷	InGaAlP/GaAlAs diode	660, 795	NM	Anterior temporal: 8 TMJ: 4	19	Three PBM therapy sessions, TMJ and anterior temporal	OHIP-14, VAS	180 Days	PBM vs. placebo Both PBM	5
Ortiz et al. ⁷⁹	GaAlAs diode	NM	125	6–9	15	Every 48 h, 3 points on TMJ	VAS	12 Days	↓ pain ($p<0.001$) PBM vs. placebo ↓ pain ($p<0.001$)	5
de Carli et al. ⁶³	GaAlAs diode	808	100	100	32	Two times a week, 10 points on TMJ and MM	VAS, MO, MM palpation	4 Weeks	PBM vs. Piroxicam (20 mg/d) was more effective ($p=0.02$)	5

(continued)

TABLE 1. (CONTINUED)

Author (ref.)	Laser properties			Sample size (n)	Treatment protocol and location	Method of evaluation	Follow-up period	Outcome	Jadad score
	Type	Wavelength (nm)	Power (mW)	Energy density (J/cm^2)					
Salmos-Brito et al. ⁶⁸	GaAlAs diode	830	40	8	Two times a week, 5 points on TMJ	VAS, MO	6 Weeks	PBM vs. placebo ↓ pain (better results in acute pain vs. chronic) ($p = 0.002$)	5
da Silva et al. ⁸¹	GaAlAs diode	780	70	52.5, 105.0	Two times a week, TMJ and MM	VAS, MO	5 Weeks	Combined PBM vs. placebo ↓ pain ($p < 0.05$), ↑ mandibular function ($p < 0.05$)	5
Sattayut and Bradley ⁶¹	GaAlAs diode	820	60, 300	21.4, 107	Three times a week, 6 points on TMJ and MM	PPT, SSL, MO, EMG	4 Weeks	Combined PBM vs. placebo ↓ pain ($p < 0.05$), ↑ EMG ($p < 0.05$)	5
Rohlig et al. ⁶²	GaAlAs diode	820	300	8	Three times a week, 5 points on TMJ and MM	VAS, PPT	3 Weeks	PBM vs. placebo ↓ pain ($p = 0.006$)	5
Marini et al. ⁵²	GaAs	910	400	NM	Five times a week for 2 weeks, TMJ	VAS, MRI	4 Weeks	PBM vs. placebo ↓ pain ($p = 0.0001$), ↑ mandibular function ($p = 0.0001$)	5
Mazzetto et al. ⁵⁴	GaAlAs diode	830	40	5	Two times a week, 4 points on TMJ	VAS, MO	4 Weeks	PBM vs. placebo ↓ pain ($p < 0.01$), ↑ mandibular function ($p < 0.05$)	3
Carrasco et al. ⁶⁹	GaAlAs diode	780	50, 60, 70	25, 60, 105	Two times a week, TMJ and MM	VAS	4 Weeks	Combined PBM vs. placebo ↓ pain ($p < 0.05$)	5
Carrasco et al. ¹	GaAlAs diode	780	70	105	Two times a week, 5 points on TMJ	VAS, CCM	4 Weeks	PBM vs. placebo NS ($p > 0.05$)	5
da Cunha et al. ⁷⁵	GaAlAs diode	830	500	100	Once a week, painful areas	VAS, CMI	4 Weeks	PBM vs. placebo NS ($p > 0.05$)	5

(continued)

TABLE 1. (CONTINUED)

Author (ref.)	Laser properties				Sample size (n)	Treatment protocol and location	Method of evaluation	Follow-up period	Outcome	Jadad score
	Type	Wavelength (nm)	Power (mW)	Energy density (J/cm^2)						
Lassemi et al. ⁷³	GaAs	905	NM	NM	48	Two sessions with a 48 h interval, 3 points on TMJ and MM	VAS	12 Months	PBM vs. placebo ↓ pain ($p < 0.001$)	5
Emshoff et al. ⁸⁰	HeNe	632.8	30	1.5	52	Two to three times a week, TMJ	VAS	8 Weeks	PBM vs. placebo NS ($p > 0.05$)	5
Çetiner et al. ⁶⁵	GaAlAs diode	830	NM	7	39	10 sessions daily for 2 weeks, tender points on MM	VAS, MO	4 Weeks	PBM vs. placebo ↓ pain ($p < 0.05$)	3
Núñez et al. ⁵³	InGaAlP diode	670	50	NM	10	One session per week, 4 points on TMJ and MM	VAS, MO	2 Weeks	PBM vs. TENS ↓ pain ($p < 0.01$), ↑ mandibular function ($p < 0.01$)	5
Kulekcioglu et al. ⁸³	GaAs diode	904	17	3	35	15 sessions, 4 most tender points	VAS, MRI	4 Weeks	PBM vs. placebo ↓ pain ($p < 0.05$)	5
Conti ⁷⁶	GaAlAs diode	830	100	NM	20	Once a week, TMJ and MM	VAS	3 Weeks	PBM vs. placebo ↓ pain ($p < 0.02$)	5

BAI, Beck anxiety inventory; CCM, colorimetric capsule method; CMI, craniomandibular index; EMG, electromyography; EXT, exercise training; FIQ, fibromyalgia impact questionnaire; GMD, geometric mean diameter; McPQ, McGill pain questionnaire; MM, masticatory muscles; MO, maximum mouth opening; MRI, magnetic resonance imaging; NM, not mentioned; NS, not significant; OHIP-14, oral health impact profile; OMES, orofacial myofunctional evaluation with scores; PPT, pressure pain threshold; RDC/TMD, research diagnosis criteria for temporomandibular disorders; SF-MPQ, short form-McGill pain questionnaire; SPBM, superpulsed low-level laser therapy; SSI, symptom severity index; TENS, transcutaneous electrical neural stimulation; TMJ, temporomandibular joint; VAS, visual analog scale.

TABLE 2. SUGGESTED PROTOCOL FOR APPLICATION OF LOW-LEVEL LASER THERAPY IN TEMPOROMANDIBULAR DISORDER PATIENTS ACCORDING TO THE PREVIOUS REVIEWED STUDIES

<i>Parameter</i>	<i>Suggested amount</i>
Laser type	GaAlAs diode
Wavelength	800–900 nm
Operating mode	Continuous
Radiation power	100–500 mW
Energy density	<10 J/cm ²
No. of irradiation points	Includes all trigger points on masticatory muscles and TMJ
Session frequency and treatment duration	Two to five times a week for 4 weeks

PBM application site

The location of PBM application varied between the included studies. PBM was applied to TMJ and masticatory muscles together in 25 studies, and to masticatory muscles only in 3 studies,^{22,65,78} and to TMJ only in 6 studies.^{52,54,59,68,79,80}

Considering the nonsignificant results, which were more common among studies that irradiated only painful points or the TMJ,^{1,59,74} it seems that it is better to apply PBM on skin of both trigger points and TMJ.^{46–48,55–57} Moreover, according to the results of the included studies, PBMT is more effective when administered on the muscles compared with TMJ. But, Emshoff et al.⁸⁰ in a well-designed study demonstrated similar effects of PBMT and placebo, which is in accordance with Herpich et al.²² One explanation, especially for Emshoff et al.'s⁸⁰ findings, is their investigated patients. They included and treated patients with PBMT who had already been resistant to conventional therapeutic approaches for TMDs, such as diet change, occlusal appliances, or topical medicines. The use of HeNe laser may also influence the outcome, considering the limited penetration of this wavelength into muscles.

PBM application protocols for TMDs

The number of therapeutic sessions performed differed considerably, ranging from 10 sessions during 2 weeks in Çetiner et al.⁶⁵ to once a week only,^{58,75,76,81} and the treatment duration varied from 10 sec to 20 min for each session. It seems that more sessions did not promote PBM efficacy when comparing three different studies of same wavelength.^{58,59,82} In the latter studies, PBM was applied for one, two, or three sessions per week, but reported a nonsignificant difference. As aforementioned, the duration of PBMT is not the only important factor, but when PBM is administered only on the masticatory muscles, longer irradiation duration should be considered that leads to positive results.⁸⁰

Considerations

In this review, many included studies support the application of PBM for the treatment of TMDs (joint and/or muscles).^{1,46–51,58,59,77,80,82,83} Further, PBM is supported as an adjunct therapeutic modality for TMDs. Thus, more positive findings could probably be achieved by combining such therapy with standard TMD therapies. Further to that, no side effects were reported in the analyzed studies. For these reasons, researchers are encouraged to further investigate the capabilities of PBM to reach more consistent protocols in treating TMD cases.

Future Direction and Conclusions

Despite the observed limitation of PMBT, it seems that PBM can relieve pain in TMD patients and improve mandibular functionality. Given the high discrepancy within the included studies in this review, we highlight the need for further precise randomized clinical trials (RCTs) with larger sample sizes to assess its efficacy. More research must clarify the uncertain issues of PBM in TMDs such as dosage, energy, power density, duration, and locations. Further, future RCTs should include appropriate power output analysis, proper allocation concealment analysis, adequate randomization method, and double-blind design. Despite the variety of parameters related to the PBMT and the difficulty of their interpretation, an evidence-based consensus about the most efficient therapeutic protocols for TMD patients can be beneficial for both future research and clinical applications.

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