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Photobiomodulation therapy as a treatment modality for the temporomandibular disorder – A Systematic Review

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Abstract:
Background: *Photobiomodulation therapy (PBMT) is the utilization of non-ionizing light sources for therapeutic outcomes. Temporomandibular disorder (TMD) usually accompanies by a wide variety of symptoms that could be painful and/or include dysfunctional jaw conditions. Photobiomodulation therapy (PBMT) has increased its interest as a treatment modality for the TMD as a non-surgical intervention during the past few years, mainly because of its easy application and the positive scientific evidence on pain reduction. The current review aims to collect the evidence, based on the literature, to evaluate the use of lasers on TMD symptoms and in specific the use of PBMT.*
Methods: *A systematic review was performed in several databases and covers from the year 2000 to 2020. A supplemental manual search was performed to identify additional studies by using references obtained from reviewed articles. Risk of Bias assessments was incorporated into synthesis, focusing on randomized controlled trials and systematic reviews. Common methods for incorporating critical appraisals into the synthesis process were sensitivity analysis, narrative discussion, and exclusion of studies at high risk of bias.The primary search objective was to identify all papers reporting the role of lasers in TMD.*
Results: *With the help of keywords, the total number of abstracts identified was 71. These abstracts were further reviewed as per inclusion and exclusion criteria and 60 abstracts were identified to match the selection criteria. Further review of full articles, 42 articles were excluded. 18 articles resulted from that matched our inclusion criteria for this study.*
Conclusions: *In conclusion, the literature-based evidence suggests that PBMT or LLLT have been shown to reduce the pain caused by the TMD significantly. It was found that 830-nm laser photobiomodulation was most adequate and effective in reducing TMD pain and symptoms when all other doses were tested.*
Keywords: *Temporomandibular disorders (TMD), Photobiomodulation Therapy, Low-level laser therapy, Temporomandibular joint (TMJ)*

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I. Introduction

TMD treatment is guided by the signs and symptoms reported by the patient. The main purpose of therapeutic approaches is to decrease symptom intensity, thereby enhancing the function of the masticatory muscles, TMJ, and adjacent anatomical structures.[1,2] Therapeutic modalities consist of the use of analgesics, anti-inflammatory agents, muscle relaxants, cryotherapy, heat therapy, transcutaneous electrical nerve stimulation (TENS), ultrasonography, acupuncture, massage, exercise, photobiomodulation therapy, and interocclusal splints.[3, 4, 5,6]

However, noninvasive techniques are preferable first choice of treatments in TMD[7, 8]. Photobiomodulation therapy (PBMT) has increased its interest as non-surgical intervention during the past few years, mainly because of its easy application and the positive scientific evidence on pain reduction.

The photobiomodulation effects of PBMT are related to the proliferation of macrophages, lymphocytes, endothelial cells, and fibroblasts.[9] Laboratory[10] and clinical trials[11,12,13]have demonstrated its analgesic and anti-inflammatory effects in musculoskeletal disorders and very few researches have focused the results on Temporomandibular disorders. The current review aims to collect the evidence, based on the literature, to evaluate the use of lasers on TMD symptoms and in specific the use of PBMT.

II. Material And Methods

PRISMA-P guidelines were followed to complete the search available literature. A comprehensive systematic literature review was conducted using the PubMed databases and google scholar. The primary search objective was to identify all papers reporting the role of lasers in TMD. The protocol was submitted and approved by the International Prospective Register of Systematic Reviews (PROSPERO)(Registration number : CRD42021271730)

Search Strategy

A comprehensive initial systematic literature review was conducted using the PubMed databases and google scholar. This systematic search includes PubMed and Medline (2010-2020), Cochrane Central Register of Controlled Trials, Embase, Web of Science, Google Scholar, the US National Institutes of Health Trials Registry, WHO Library, Medline with no language filter. Additional dental organization websites were searched, including the American Dental Association, to identify articles and statistics that evaluated the effectiveness of the lasers on TMD. The search strategies were developed to cover publications from January 2010 through March 2020. Past 10 years of search was selected as per Investigators to compare the different lasers that can be use in TMD's management.

Selection criteria

The primary search objective was to identify all papers reporting the results of
(1) Randomized clinical trials (RCT) of lasers and TMDS; and
(2) Both randomized / non-randomized clinical trials and case reports on the use of lasers in TMD.
The first step was to identify and review all of the studies listed for analysis in two major literature reviews, a Cochrane Collaboration review[14] and a second systematic literature review published by the National Institutes of Health Research (NIHR) [15] on the use of lasers in TMD management [16]. The second step was an extensive search of the PubMed/MedLine database, initiated using the following combined search terms: "Nd YAG and temporomandibular joint" (n =8); "Nd YAG and temporomandibular disorder" (n =5); and photobiomodulation and temporomandibular disorder" (n = 22); photobiomodulation and TMJ (n= 21). From these lists, studies were identified that (a) did not replicate studies already found and (b) were otherwise eligible for inclusion. The third and final step was a review of all reference lists and tables of other studies found within papers identified in the second step.
Articles were considered for inclusion into the study by reviewing the titles and abstracts of all retrieved studies. The study authors SS, BG and MK did the review and results were compiled to ensure no studies were missed. The full text of selected studies was then analyzed to ensure that the following inclusion criteria were met: diagnosis of TMD or myalgia, and the paper referred to pain management in TMD.

Search Terms/ keywords:

Inclusion criteria
The literature included in this study was based on to the following inclusion criteria:
1. Studies / Case reports on management of TMD with the help of lasers.
2. Randomized clinical trials on laser management of TMD
3. Studies / literatures or case reports for management of pain in TMD.

Exclusion criteria
The literature eligible for inclusion in this study was based on the following exclusion criteria:
1. Literature / studies or case reports on conventional surgical management of sleep apnea.
2. Literatures / studies reporting the laser assisted surgical management TMD.
3. Literature on previous treatment history of TMD other than photobiomodulation.

Selection of studies & data extraction

The articles were evaluated for their relevance based on the titles and abstracts. Further validity of the articles was done by obtaining the full text of the possible relevant studies that met the inclusion criteria. All the

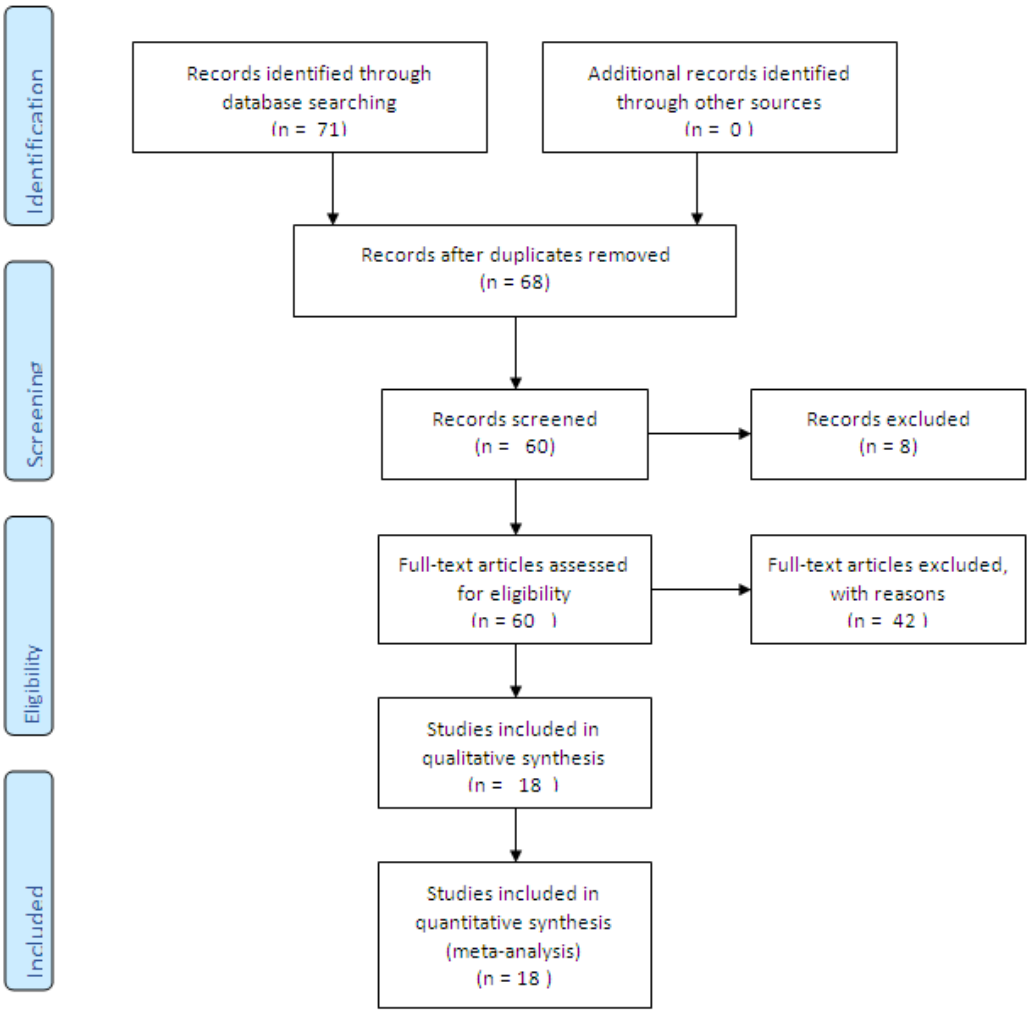
articles were reviewed by three reviewers (SS, BG and MK). The studies assessed by SS and deemed eligible were checked by MK and BG for methodological quality and inclusion criteria. All disagreements were resolved verbally, with strict adherence to the predetermined inclusion criteria. Risk of bias analysis is mentioned in **Fig.1**

III. Results

With the help of keywords, the total number of abstracts identified was 71. These abstracts were further reviewed as per inclusion and exclusion criteria and 60 abstracts were identified to match the selection criteria. Further review of full articles resulted in 18 articles that matched our inclusion criteria. 42 articles were excluded. There were no articles identified in our manual search.

Our comprehensive search resulted in the selection of 18 articles: 7 Randomized controlled trials, 2 Clinical trials, 2 animal studies and 2 systematic reviews. 5 of the studies are ongoing projects and still awaiting final results. (Refer table -1 and 2).
The flow chart in **Fig. 2** depicts the search strategy for this study.

PRISMA 2009 Flow Diagram



IV. Discussion

The present systematic review mainly focused on the scientific literature based evidence pertaining to the treatment of temporomandibular joint disorder by Photobiomodulation (PBMT) and low level laser therapy (LLLT). The use of PMBT is a non-invasive treatment of TMD that has shown to provide significant reduction in pain. Several clinical trials (Borges et al17, Costa et al18, Herpich et al19, Madani et al20 and Nadershah et al21) have been performed on the use PMBT for TMD's and have suggested the use of PMBT in chronic pain symptoms gets better and the function of the joint also improves. PMBT/LLLT has been found to benefit the masticatory muscles (Madani et al20) and can be of great use in myofascial pain conditions a s well.

A clinical study by Vitor et al[22] showed that a synergistic use of ultrasound and PBMT was effective in pain reduction in patients with TMD. Borges et al[17]compared the efficacy of three different photobiomodulation dosimetries in the treatment of patients with TMD. All the groups receiving different doses of photobiomodulation significantly reported decreased pain ($p < 0.05$). 830-nm laser photobiomodulation was effective in reducing TMD pain and symptoms at all doses tested. Doses of 8 J/cm2 are effective in improving range of motion (maximal opening and protrusion of the mandible).

Costa et al[18]assessed the efficacy of photobiomodulation therapy (830 nm) for myalgia treatment of masticatory muscles in 60 patients. PBMT (830 nm) reduces pain in tender points, but does not influence the extent of mouth opening in patients with myalgia (refer table 3).[16, 23]

Herpich et al[19]evaluated the effect of intraoral photobiomodulation involving super-pulsed laser (905 nm) combined with red (640 nm) and infrared (875 nm) light-emitting diodes on pain, mandibular range of motion, and jaw functioning in temporomandibular disorder. The findings demonstrate that intraoral photobiomodulation involving super-pulsed laser (905 nm) combined with red (640 nm) and infrared (875 nm) light-emitting diodes diminishes pain and improves functioning.[18, 24]

Madani et al[20] compared the efficacy of low-level laser therapy (LLLT) versus laser acupuncture therapy (LAT) in patients with temporomandibular disorders (TMDs). They concluded that overall pain intensity and pain degree at masticatory muscles (except temporal muscle) and TMJs were significantly lower in both experimental groups than the placebo group at most intervals after therapy ($p < 0.05$). Both LLLT and LAT were effective in reducing pain and increasing excursive and protrusive mandibular motion in TMD patients. LAT could be suggested as a suitable alternative to LLLT, as it provided effective results while taking less chair time.[19, 25]

Nadershah et al[21]examined the effectiveness of photobiomodulation in the treatment of myofascial type TMD. Based on their assessment, they believed that photobiomodulation has proven to be successful and efficient treatment modality for the myofascial TMD pain for the short-term. However, the long term effect of the sub groups warrants further research. The study also believed that photobiomodulation is a noninvasive, easy to perform with minimal or no systematic side effects.[20, 26]

The mechanism of action of photobiomodulation is not yet fully understood.[26, 27] It is known that photobiomodulation can influence the synthesis and release of several substances involved in analgesia. [31] The theories report that there is a release of endogenous opioids, increased urinary excretion of glucocorticoids, increased ATP production, stimulation of local microcirculation, and decreased cell hypoxia.[28,29] Other authors further affirm increased level of beta-endorphins, reduced bradykinin expression, and release of histamine associated with increased lymphatic flow and blood circulation, controlling the inflammation process and inducing muscle relaxation.[31,32] In addition, Karu et al also described that the effects of photobiomodulation are mainly due to increased oxidative metabolism in mitochondria.[28,29] One of the most important chromophores is the enzyme cytochrome c oxidase, which absorbs light in the region close to the infrared spectrum.[27,28] The main hypothesis is that photons dissociate inhibitory nitric oxide from this enzyme, leading to an increase in electron transport and ATP production.[27,28] Another hypothesis suggests activation of light-sensitive ion channels, which allow calcium to enter the cell, triggering signaling pathways through reactive oxygen species (ROS), cyclic AMP, nitric oxide, and Ca2+, leading to activation of transcription factors, which may increase the expression of genes related to protein synthesis, cell migration and proliferation, anti-inflammatory signaling, anti-apoptotic proteins, and antioxidant enzymes. [27, 28]

In photobiomodulation therapy, three mechanisms at discrete cellular sites have been identified for their interactions with photoreceptive targets. While an individual mechanism appears to dominate specific therapeutic applications (performance, analgesic versus regenerative), it is increasingly evident there is significant crosstalk amongst them in individual clinical scenarios.[29]

V. Conclusion

In conclusion, the literature based evidence suggests that PBMT or LLLT have shown to reduce the pain caused by the TMD significantly. It was found that 830-nm laser photobiomodulation was most adequate and effective in reducing TMD pain and symptoms when all other doses were tested. Although the PBMT (830 nm) reduces pain in tender points, it seems to be less effective in improving the range of motion for mouth opening in patients with myalgia. Combined use of LLLT and LAT were effective in pain management and improving the excursive and protrusive mandibular motion in TMD patients. Current evidence suggests LAT to be best suitable alternative LLLT, as it can provide effective results with less chair time. Studies have suggested that PBMT is non-invasive, easy to apply with no significant reported systemic side effects. However, there is not enough evidence on the long-term effect and its effect on different subtypes. The use of LLLT is evidently effective but its long term use on TMD needs further investigation.

The effectiveness of photobiomodulation as in the treatment of TMD has been proven by several authors. The results mainly suggest that PBMT significantly reduces pain with some improvements in the jaw movements especially in lateral and protrusive excursions of jaw. This review supports and believes that Photobiomodulation is a good adjunctive non-invasive treatment for the TMD's with no to minimal reported side effects.

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Table: 1 Details of the included studies: Purpose, signs, intervention and control

Author	**Type of Study**	**Animal/Human**	**Purpose of Study**	**Diagnostics**	**Sign and Symptoms**	**Intervention**	**Control**
Dantas CMG et al, (2020 Mar)	Randomized, controlled, double-blind clinical trial	Human	Evaluating pain relief and mandibular mobility in TMD patients following treatments with 2 laser wavelengths, red (660nm) and infrared (808nm) individually and combined as compared to a placebo.	Research Diagnostic Criteria for Temporomandibular Disorders	Myalgia and arthralgia, with or w/o disk displacement. TMJ-related pain greater than score 4, measured with VAS, after 2 weeks of guided self-care	PBMT compared to SHAM	AsGaAl infrared laser (Therapy XT; DMC), 808 nm 88 J/cm2, 100 mW 30 s/point, spot size 0.034 cm2, 3 J/point, in continuous mode and with the tip positioned at 90° to the skin.
Nadershah M (2020 Mar)	Randomized, controlled, double-blind clinical trial	Human	Examination of the effectiveness of photobiomodulation in the treatment of myofascial type TMD.	NA	Unilateral TMJ and masticatory muscles pain during function divided into two groups	NA	Control group that received a sham laser treatment every 48 h for 10 days
Tunér J (2019 Dec)	Systematic review		photobiomodulation therapy (PBMT) application in temporomandibular disorder (TMD) patients and to suggest an evidence-based protocol for therapeutic PBM administration	Temporomandibular joint pain and dysfunction in masticatory muscles is characterized in TMDs.	NA	NA	NA
Vitor Hugo Panhóca (2019 Nov)	Prospective	Human	analyze the oral health-related quality of life (OHRQoL) of patients with temporomandibular disorders (TMDs) who were treated simultaneously with ultrasound (US) and photobiomodulation therapy (PBMT).	Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD)	Articular, muscular, or mixed TMDs, diagnosed according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD)	US and PBMT in the same system	NA
Madani A (2020 Feb)	Randomized double-blind clinical trial	Human	This randomized double-blind clinical trial aimed to compare the efficacy of LLLT versus LAT (without irradiation on Ashi points) on pain intensity and mandibular range of motion in TMD-affected patients.	Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD))	Limited mouth opening or function. Presence of pain in masticatory muscles and/or TMJs, either in clenching or in jaw movements (TMD muscular	NA	Laser acupuncture therapy: 8-10 nm diode laser was emitted bilaterally on acupunctu

					disturbance (class Ia, Ib) or arthralgia (class IIIa), Based on Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD))		re points / placebo group received no laser therapy
João Ignácio Ferrara-Jr (2019 Apr)	Prospective	Animal	The effects of PBM, as well as the mechanisms involved were evaluated in experimental model of TMD in rats.	Testing mechanical sensitivity (von Frey, EFF 301, Insight, Ribeirão Preto/SP, Brazil) based on the method of Denadai-Souza / Mechanical hyperalgesia	NA	NA	NA
Fernando Rodrigues Carvalho (2019 Apr)	Randomized double-blind clinical trial	Human	PBMT is effective for use in palliative care of TMD and orofacial and cervical skull pain	RDC/ TMD / TMJ and orofacial/cervical muscles. Measurement of the mouth opening and mandibular movements using a ruler and caliper. Verifying collecting presence and types of articular sounds; and - Information on parafunctional habits, bruxism, pain, psychological aspects, and chewing	NA	NA	No laser therapy
Sousa DFM (2019 Feb)	Controlled randomized double-blind clinical trial	Human	effects of photobiomodulation with simultaneous use in a single light emitting diode device—red LED (660 nm) and infrared LED (850 nm) on pain, amplitude of mandibular movements, and in electrical activity of masticatory muscles in individuals with temporomandibular dysfunction	Research Diagnostic Criteria for Temporomandibular Disorder—RDC/TMD	TMD, divided by the degrees of this dysfunction based on the Research Diagnostic Criteria for Temporomandibular Disorder—RDC/TMD Have complete dentition (except third molars). Mandibular deviation; and/or deflection	NA	NA
Fernanda Thomé BROCHADO (2018 Jul)	Single-center, randomized, single-blind study received	Human	Study aimed to compare the effectiveness of PBM and MT, alone or combined, in the treatment of pain, movement restriction, psychosocial disorders, and anxiety symptoms of TMD.	VAS, RDC/TMD (Axis I and II), Beck Anxiety Inventory (BAI).	NA	Photobiomodulation group (GPBM) /Manual Therapy Group (GMT)	NA
Borges RMM (2018 Dec)	RCT, pilot study	Human	Compare the efficacy of three different photobiomodulation dosimetries in the treatment of patients	TMJ mobility assessed through computerized biophotogrammetry	TMD in groups Ia and Ib (chronic myofascial pain in accordance with RDC/TMD)	Photobiomodulation	Placebo group

			with temporomandibular dysfunction.				
Ana Paula Taboada Sobral, (2018 May)	RCT	Human	Estimate the direct costs for treatment of chronic muscle pain with photobiomodulation therapy, occlusal splint and placebo in patients with TMD. Evaluate the effectiveness of photobiomodulation therapy and occlusal splint for treatment of muscle pain in patients with TMD. Analyse the cost-effectiveness of the two proposed treatments for pain; and Describe and compare the results of the analyses of these treatments	RDC/TMD	NA	Laser, splint and placebo	Occlusal splint / placebo
Langella LG (2018 Jan)	RCT	Human	to analyze the effect of laser therapy and LED therapy on pain and function in patients with TMD and its association with neck pain.	Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD)	TMD	Laser and LED laser group will have three points irradiated, while those in the LED group will have 36 points irradiated	NA
Douglas De Oliveira DW (2017 Nov)	Randomized double blinded clinical trial	Human	Determine the survival rate of treatment with red (660 nm) and infrared (790 nm) laser in cases of TMDs.	NA	NA	NA	NA
da Silva MM (2015 Jun)	Randomized controlled clinical trial	Human	Study aimed to assess the potential role of exercise training plus phototherapy in reducing chronic pain in women with FM and TMD. A further aim is to determine whether the interventions can improve quality of life and modulate endogenous serotonin.	McGill Pain Questionnaire, and pain thresholds were punctuated using a digital algometer. FM symptoms will be assessed using the Fibromyalgia Impact Questionnaire, and quality of life will be determined with the 36-item Short Form Health Survey / Serotonin levels will be evaluated in salivary samples using a competitive enzyme-linked immunosorbent assay. Research diagnostic criteria (axes I and II)	FM and TMD	(no intervention / phototherapy intervention (PHO)/ muscle-stretching, aerobic, and facial exercises (EXT)/ phototherapy plus exercise interventions (PHO + EXT)	NA

Herpich CM (2020 Mar)	Randomized, sham-controlled, double-blind clinical trial	Human	Study aimed to evaluate the effects of intraoral photobiomodulation involving super-pulsed laser (905 nm) combined with red (640 nm) and infrared (875 nm) light-emitting diodes on pain, mandibular range of motion, and functioning in women with myogenous TMD	RDC/TMD	Diagnosis of myogenous and/or mixed TMD	Treatment group and sham group.	Sham
de Freitas Rodrigues A (2019 Jul)	Prospective	Animal	analyze the effects of PBM on nociceptive behavior and neuronal activity of the trigeminal nucleus after unilateral TMJ disc injury in rats.	NA	NA	Surgical injury of the articular disc (Op)surgical injury of the articular disc and PBM (Op + PBM)/ sham-operated submitted to PBM (SHAM + PBM) / control without joint injury or PBM (Naïve)	Sham
Costa SAP (2017 Dec)	RCT	Human	effects of PBMT (830 nm) regarding analgesia of the masticatory muscles.	Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD)	Myalgia of the temporalis and masseter muscles after initial examination and independent of the final diagnosis of TMD	PBMT	Placebo
Demirkol N (2015 Apr)	Prospective study	Human	Evaluate the effects of low-level laser (Nd:YAG) therapy and occlusal splints in patients with signs and symptoms of temporomandibular disorders (TMD) characterized with myofascial pain (MP)	Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TDM)	NA	Occlusal splint (OS) group A (n = 10), the second was low-level laser therapy (LLLT) group B (n = 10), and the last group C was placebo (n = 10)	Placebo group

Table: 2 – Results and conclusions

Author	**Results**	**Conclusions**
Dantas CMG (2020 Mar)	Ongoing recruitment	No conclusion yet
Nadershah M (2020 Mar)	There was a significant difference in VAS scores between the test and control groups with the test group scoring lower.	Photobiomodulation therapy proved to be an effective short-term therapeutic modality for myofascial TMD pain. It is non-invasive, easy to apply with no systemic side effects. Its long-term effect and its effect on different subtypes of TMD need further investigation.
Tunér J (2019 Dec)	0.75 to 112.5 J/cm2 with 0.9–500 mW power was found to be a window protocol for light application. Best results for pain relief and mandibular movement enhancement were reported after	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

	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.	beneficial for both future research and for clinical applications.
Vitor Hugo Panhóca (2019 Nov)	NA	Synergistic treatment with US + PBMT improved the OHRQoL of patients with TMDs, and its beneficial effects persisted 1 month after termination of treatment.
Madani A (2020 Feb)	NA	Overall pain intensity at rest condition was significantly lower in both LLLT and LAT groups / The masticatory muscles including masseter (body, origin, insertion), tendon of temporal, and insertion of internal pterygoid responded well to LLLT and LAT, so that pain intensity in these areas was significantly lower than those in the placebo group at most intervals after therapy / TMJ at both rest and function were significantly lower in LLLT
João Ignácio Ferrara-Jr (2019 Apr)	Morphological analysis of the masseter muscle demonstrated that PBM *reverses* the intense inflammatory reaction induced by CFA / PBM significantly decreased FKT-IR reduced significantly in TG / single application of PBM therapy was able to reverse the observed nociception up to 6 h of evaluation	PBM induces true antinociception, through the central inhibition of fractalkine, in rats submitted to an experimental model of TMD
Fernando Rodrigues Carvalho (2019 Apr)	NA	NA
Sousa DFM (2019 Feb)	NA	NA
Fernanda Thomé BROCHADO (2018 Jul)	NA	The present findings indicated: All protocols tested were able to decrease pain and improve mandibular movements and some mandibular functions, reducing negative effects of the psychosocial aspects and the anxiety symptoms of TMD patients. Results showed that therapies improve functional capacity and the resume of daily activities. Combination of PBM and MT did not promote an increase in the effect of both therapies alone.
Borges RMM (2018 Dec)	NA	Demonstrated a significant reduction of TMD pain and symptoms in all the photobiomodulation protocols used, including the placebo group. No significant differences were observed between the different dosimetry protocols used. The 8-J/cm2 group showed a positive effect on the mandible protrusion movements. Hence, lower fluence doses need smaller exposition time, optimizing the association of other therapeutic approaches in the TMD approach.
Ana Paula Taboada Sobral1, (2018 May)	NA	NA
Langella LG (2018 Jan)	NA	NA
Douglas De Oliveira DW (2017 Nov)	The survival rate for red and infrared laser was 0.24 and 0.30, respectively, at 180 days. Grinding teeth and headache were associated with recurrent pain.	Both lasers were effective in the treatment of TMD symptoms and had a low survival rate at 180 days.
da Silva MM (2015 Jun)	NA	NA
Herpich CM (2020 Mar)	NA	Intraoral photobiomodulation involving super-pulsed laser (905 nm) combined with red (640 nm) and infrared (875 nm) light-emitting diodes diminishes pain and improves functioning in women with myogenous temporomandibular disorder.
de Freitas Rodrigues A (2019 Jul)	NA	It was concluded that after an experimental physical lesion applied to the TMJ disc, there was a total reversal of the nociceptive threshold, as well as a decreased expression of substance P, TRPV-1, and CGRP in animals treated with low-level laser therapy photobiomodulation.
Costa SAP (2017 Dec)	NA	The photobiomodulation therapy (830 nm) acted effectively on the analgesia of the masticatory muscles in the participants with TMD, based on muscular palpation, but was not effective regarding the criteria for mouth opening range. Further

		research is needed to evaluate the long-term effects of PBMT (830nm) on the treatment of patients with chronic pain from temporomandibular disorders.
Demirkol N (2015 Apr)	NA	This particular type of LLLT (1,064 nm, 8 j/cm2, 250 mW output power) was as effective as OST (12 h/day for 3 weeks) for pain reduction in patients with myofascial pain dysfunction syndrome according to the present placebo controlled randomized clinical trial. LLLT and OST groups were effective according to placebo group. There was no statistically significant difference in placebo group. There were no negative side effects reported under the conditions of this study.

Table: 3 – Laser types, Laser power, locations and sessions

Author	**Laser type**	**Power of laser**	**Location of application**	**Number of sessions**
Dantas CMG (2020 Mar)	InGaAlP red laser (Therapy XT; DMC), 660 nm, 88 J/cm2, 100 mW, 30 s/point, spot size 0.034 cm2, 3 J/point, in continuous mode and with the tip positioned at 90° in contact with the skin.	NA	Anterior to the mandibular condyle and intra-auricular toward the TMJ. The masticatory muscles will also be accessed, with a 2-point irradiation on the superficial masseter muscle and 2 points on the anterior temporal muscle bundle. The irradiation points will be equally distributed within the muscle area.	NA
Nadershah M (2020 Mar)	PBMT	257 J per treatment and a total dose of 1285 J for the entire treatment	NA	NA
Tunér J (2019 Dec)	NA	NA	NA	NA
Vitor Hugo Panhóca (2019 Nov)	NA	Laser diode at 808 nm, power 100 mW, Spot area 1.76 mm^2 frequency of 1.0 MHz, intensity 1 W/cm2, 50% pulsed work cycle, Effective radiation area of 1.6 cm2	For 120 sec per region to the masseter muscle, anterior temporalis muscle, and TMJ on the left and right sides of the face, with gentle slow circular movements.	Two sessions per week for 4 weeks, a total of eight sessions
Madani A (2020 Feb)	Low power gallium aluminum arsenide (GaAlAs) diode laser (DD2, Thor, England)	810 nm (Gaussian beam profile) and was employed in contact and continuous-wave mode with the output power of 200 mW ; 30 s per point, giving 6 J of energy with energy density (dose) of 21 J/cm2 to each painful area (surface area of the probe aperture 0.28 cm2)	Bilateral muscles including masseter (origin, body, and insertion), temporal (anterior, middle, posterior), tendon of temporal, and insertion of internal pterygoid as well as temporomandibular joints (TMJs) at rest and function were palpated and the painful points were recorded in the patient's folder ; posterior and superior of the mandibular condyles, and inside the external acoustic meatus	Laser was applied two times a week for 5 weeks
João Ignácio Ferrara-Jr (2019 Apr)	NA	A low-level semiconductor indium gallium aluminum phosphorus (InGaAlP) (Photon Laser III, D.M.C., São Carlos, Brazil) emitting a wavelength of red 660 nm was used through the experiments with a beam spot of 0.2 cm2 and an output power of 30 mW, energy density of 1.6 J/cm2, and exposure time of 15 s in a continuous frequency	Left masseteric region	NA
Fernando Rodrigues Carvalho (2019 Apr)	NA	808 nm wavelength, power 100, density (J/cm^2) 105, Output spot area (cm^2) 0.028; Energy/point (J) 3	Trigger points	3 in duration of 2 weeks / Number of sessions per week 1

Sousa DFM (2019 Feb)	NA	18 red LEDs—660 nm and 18 infrared LEDs—850 nm, radiant exposure of 5.35 J/cm2 , total power radiated by LEDs of 63mW, irradiation of 4.45mW/cm2 per point with an exposure time of 1200 seconds, resulting in an energy of 75 J per point, and total irradiated energy of 453.6 J per volunteer. The application will be in contact with the skin and the area of each beam of 0.7854 cm2	Masseter muscles and anterior portion of the temporal muscles, bilaterally	3 times a week with interval between sessions, for 2 weeks, totalizing 6 treatment sessions
Fernanda Thomé BROCHADO (2018 Jul)	GaAlAs diode laser	MMOptics Recover, São Paulo, Brazil), with a wavelength of 808 nm. Irradiation was performed in punctual contact mode with a spot size of 0.03 cm2, power output of 100 mW, irradiance of 3.33 W/cm2, radiant exposure of 133 J/cm2, 40-s exposure time per point, and 4 J of total energy per point	5 in the TMJ region (superior, anterior, lateral, posterior, and postero-inferior to the condyle) and 7 in muscles [temporal (anterior, middle, and posterior), masseter (upper, middle, and lower portion), and insertion of the medial pterygoid],	12 times (3 times a week for 4 consecutive weeks)
Borges RMM (2018 Dec)	Low-level aluminum gallium arsenide (AlGaAs) laser (brand Ibramed®, model Laserpulse Diamond Line) previously calibrated, with a wavelength of 830 nm, power of 30 mW/cm2, and contact area of 0.01160 cm2	8, 60, and 105 J/cm2 group,	TMJ / preauricular region and in the external acoustic meatus	Three times a week, totaling ten sessions, with three levels of energy density.
Ana Paula Taboada Sobral1, (2018 May)	Gallium-aluminium-arsenide laser	780 nm, with an energy density of 25 J/cm2, a power of 50 mW and power density of 1.25 W/cm2, will be used for a duration of 20 s per point, resulting in a total energy of 1J per point, using a conventional tip in contact with the skin, thus considering an area of 0.04 cm2, in accordance with the protocol	Masseter muscle (upper, middle and lower bundles) and one point in the anterior temporalis on each side of the face	Twelve laser applications will be applied, with two sessions per week
Langella LG (2018 Jan)	Wavelength (nm) 780 ; Target area (cm^2) 130 ; Spot area (cm^2) 43; Power (mW) 60 ;Irradiation time (s) 600 ; Points irradiated 3 ; Energy per point (J) 36 ; Radiant exposure (J/cm2) 0.8 ; Irradiance (mW/cm^2) 1.38	NA	Temporomandibular joint region: around the temporomandibular joint. Masseter and temporal muscles: on the masseter and the anterior temporal.	Twice a week for four weeks
Douglas De Oliveira DW (2017 Nov)	Laser irradiation with 4 j/cm² in the TMJs and 8 j/cm² in the muscles	NA	One side of the face (half face) was randomly selected to receive intervention, in a total of 116 sensitive points	Three sessions

da Silva MM (2015 Jun)	PainAway™ nine-diode cluster portable device (Multi Radiance Medical, Solon, OH, USA)	Irradiated for 300 s, in which 39.3 J of total energy will be delivered for each irradiation point. Wavelength of lasers (nm) 905 Frequency (Hz) 1000 Average optical output (mW) 0.9 Power density (mW/cm^2) 2.25 Peak power (W) 8.5 Dose (J) 0.3 Energy density (J/cm^2) 0.75 Spot size of laser (cm^2) 0.4 Number of LEDs 4 Red Wavelength of LEDs (nm) 640 (±10) Frequency (Hz) 2 Average optical output (mW), each 15 Power density (mW/cm^2), each 16.66 Dose (J), each 4.5 Energy density (J/cm^2), each 5 Spot size of LED (cm^2), each 0.9 Number of LEDs 4 Infrared Wavelength of LEDs (nm) 875 (±10) Frequency (Hz) 16 Average optical output (mW), each 17.5 Power density (mW/cm^2), each 19.44 Dose (J), each 5.25 Energy density (J/cm^2), each 5.83 Spot size of LED (cm^2), each 0.9 Magnetic field (mT) 35 Treatment time (s) 300 Aperture of device (cm^2) 4 Total energy delivered (J) 39.3	In the tender points in which pain has been reported by the participants. These tender points can be occipital, cervical (near the C7), trapezius, supraspinatus, second costochondral joint, lateral epicondyle and gluteal/sacrum, and greater trochanter on the medial knee border	NA
Herpich CM (2020 Mar)	Portable cluster of nine diodes (PainAway/PainCure®, Multi Radiance Medical®, Solon, OH, USA): one laser diode (905 nm), four red LED diodes (670 nm), and four infrared LED diodes (875 nm LED)	Number of lasers 1 super-pulsed infrared Wavelength of laser (nm) 905 Frequency (Hz) 1000 Mean optic output (mW) 0.9 Peak power (W) 8.5 Total dose (J) (300 s) 0.27 Size of laser tip (cm^2) 0.4 Number of LEDs 4 red Wavelength of LED (nm) 640 Frequency (Hz) 2 Mean optic output (mW) 15 Dose (J) of each emitter (300 s) 4.5 Total dose (J) (300 s) 18 Size of tip (cm^2) 0.9 Number of LEDs 4 infrared Wavelength of LED (nm) 875 Frequency (Hz) 16 Mean optic output (mW) 17.5 Dose (J) of each emitter (300 s) 5.25 Total dose (J) (300 s) 21 Size of tip (cm2) 0.9 Magnetic field (mT) 35 Treatment time (s) 300 Aperture of device with adapter (cm2) 0.394 Total energy delivered (J) 39.27 Energy density per point (J/cm2) 99.67	Lateral pterygoid muscle and sphenoid plate	Six sessions of photobiomodulation were held at a frequency of three times a week for 2 weeks according to the respective groups
de Freitas Rodrigues A (2019 Jul)	GaAs laser (gallium arsenide, Laserpulse Laser, IBRAMED	Manufacturer IBRAMED Model identifier LASERPULSE Diamond Emitter type GaAs Parameters of irradiation Center wavelength (nm) 904 nm Operating mode Pulsed Frequency (Hz) 9500 Hz Pulse on duration (s) 60 ns Beam shape Circular Parameters of treatment Beam spot size at target (cm2) 0.13 cm2 Exposure duration (s) 18 s	TMJ and more four points, one superior, one anterior, one inferior, and one posterior, to this joint, all with 3 mm of distance between them, without tip movement	10 sessions, performed every 2 days

		Radiant exposure (J/cm2) 10.38 J/cm2 Radiant energy (J) 6.75 J Number of points irradiated 5 Area irradiated (cm2) 0.62 cm2 Application technique Without skin contact Number and frequency of treatment sessions 10 sessions, performed every 2 days Total radiant energy (J) 6.75 J per session, 67.5 J over all sessions		
Costa SAP (2017 Dec)	A Thera Lase® (DMC EquipamentosLtda, São Carlos, Brazil) infrared laser (830 nm) was used for the irradiation at the following settings: power: 100 mW, energy density: 100 J/cm^2, exposure: 28 seconds at each irradiation point, and energy: 2.8 J per point	Laser beam was 0.028 cm2	Five irradiation points / on each side of the face (temporal muscle: anterior, medium, and posterior; and superficial masseter muscle: superior and inferior)	NA
Demirkol N (2015 Apr)	Approximately 8 J/cm^2 by applying 0.25 W output power for 20 s. The LLLT was applied precisely and continuously onto the trigger points. The patients were exposed to the laser application at a 1 cm^2 distance while seated in a dental chair with their necks supported, five times per week, for a total of ten sessions	025 w, 8 j/cm^2	Each muscle TrP	Five times per week, for a total of ten sessions

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