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ORIGINAL ARTICLE

Evaluation of low-level laser therapy in patients with acute and chronic temporomandibular disorders

Janaina Andrade Lima Salmos-Brito · Rebeca Ferraz de Menezes · Camila Epitácio Cravo Teixeira · Raphaella Karlla Machado Gonzaga · Breno Henrique Mara Rodrigues · Rodivan Braz · Ricardo Viana Bessa-Nogueira · Marleny Elizabeth Márquez de Martínez Gerbi

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Abstract The purpose of this study was to address the following question: among patients with acute or chronic temporomandibular disorders (TMD), does low-level laser therapy (LLLT) reduce pain intensity and improve maximal mouth opening? The sample comprised myogenic TMD patients (according Research Diagnostic Criteria for TMD). Inclusion criteria were: male/female, no age limit, orofacial pain, tender points, limited jaw movements and chewing difficulties. Patients with other TMD subtypes or associated musculoskeletal/rheumatologic disease, missing incisors teeth, LLLT contra-indication, and previous TMD treatment were excluded. According to disease duration, patients were allocated into two groups, acute (<6 months) and chronic TMD (≥6 months). For each patient, 12 LLLT sessions were performed (gallium–aluminum–arsenide; λ= 830 nm, P=40 mW, CW, ED=8 J/cm^2). Pain intensity was recorded using a 10-cm visual analog scale and maximal mouth opening using a digital ruler (both recorded before/after LLLT). The investigators were previously calibrated and blinded to the groups (double-blind study) and level of significance was 5% ($p<0.05$). Fifty-eight patients met all criteria, 32 (acute TMD), and 26 (chronic TMD). Both groups had a significant pain intensity reduction and maximal mouth opening improvement after LLLT (Wilcoxon test, $p<0.001$). Between the groups, acute TMD patient had a more significant pain intensity reduction (Mann–Whitney test, $p=0.002$) and a more significant maximal mouth opening improvement (Mann–Whitney test, $p=0.011$). Low-level laser therapy can be considered as an alternative physical modality or supplementary approach for management of acute and chronic myogenic temporomandibular disorder; however, patients with acute disease are likely to have a better outcome.

Keywords Temporomandibular joint disorders · Facial pain · Myofacial pain · Low-level laser therapy

J. A. L. Salmos-Brito
Dental School, University of Pernambuco,
Pernambuco, Brazil

R. F. de Menezes
Dental School, University of Pernambuco,
Recife, Brazil

C. E. C. Teixeira
Dental School, Federal University of Pernambuco,
Recife, Brazil

R. K. M. Gonzaga · B. H. M. Rodrigues
Clinical Practice,
Recife, Brazil

R. Braz · M. E. M. de Martínez Gerbi
Center for Laser Therapy, Dental School,
University of Pernambuco,
Recife, Brazil

R. V. Bessa-Nogueira
Dental School, Federal University of Alagoas,
Maceió, Brazil

J. A. L. Salmos-Brito (✉)
Departamento de Odontologia Restauradora,
Faculdade de Odontologia de Pernambuco,
Avenida General Newton Cavalcanti n1650, CEP 54753-220
Camaragibe, Pernambuco, Brazil
e-mail: janainasalmos@hotmail.com

Introduction

Temporomandibular disorders (TMD) are a collective term used to describe a number signs and symptoms involving the temporomandibular joints, masticatory muscles, and associated structures. Approximately 60–70% of the general population has at least one sign of a temporomandibular disorder which include limited mouth opening, clicking, and locking [1, 2]. TMD is frequently associated with pain in regions outside of the immediate joint area (such as recurrent headaches and neck pain) [1, 3]. Patients afflicted with a severe TMD can experience significant reductions in quality of life and everyday activities (such as eating, talking, yawning, and laughing) [4].

The majority of patients suffering from TMD obtain relief of symptoms with different treatments [1, 5]. The use of low-level laser therapy (LLLT) for the treatment of musculoskeletal pain syndromes has become a common practice and the affected region is usually irradiated aiming attenuation of sign and symptoms [6-16]. LLLT was introduced in a clinical randomized controlled trial on musculoskeletal pain as early as in 1980 [17] and it presents biologic effects (such as increased pain tolerance due to changes in cellular membrane potency, vasodilatation, reduction of edema, increase in intracellular metabolism and acceleration of wound healing) [18]. Moreover, the LLLT biomodulatory effect improves local microcirculation and oxygen supply to hypoxic cells in the painful areas. Simultaneously, the asphyxia of the tissue is reduced to a minimum and the removal of collected waste products takes place. The microcirculation normalization obtained due to laser applications interrupts the "circulus vitiosus" which originates, develops and maintains pain and brings a normal physiological condition back to the tissue [7, 19].

Advantages of this therapy include partial or total pain relief, excluded or reduced use of analgesic drugs, no infections, no cardiovascular dysfunctions, and no after effects (anesthesia dolorosa). LLLT is well tolerated by any age and it is painless, aseptic, cost effective, and not labor intensive. Thus, LLLT is almost free of side effects and no negative or pathological effects on the human body were reported by the literature [7]. Moreover, LLLT is also important for reducing costs of treatment, as patients have less need for surgical treatment or medicine use (e.g., painkillers) during treatment and the quick improvement observed during treatment also has a positive psychological effect, especially on patients suffering from long-term symptoms [9].

Some authors suggest that the LLLT can be used as monotherapy or as supplementary approach to other therapeutic procedures for TMD pain [7, 10, 14, 20, 21]. However, clinicians and researchers still face two clinical issues: limited information exists about the effects of LLLT in TMD patients, specially, if there is a difference among TMD subpopulations (acute or chronic) [7, 16] and the therapeutic value of LLLT remains controversial as the literature report conflicting results in TMD patients [6, 10, 11, 15, 16, 21, 22].

The purpose of this study was to address this clinical question: among patients with acute or chronic TMD, does low-level laser therapy reduce the pain intensity and improve maximal mouth opening?

Methods

Ethics issues and population

This study was approved by University of Pernambuco Research and Ethics Review Board (protocol #054/2008). All study phases were accomplished in agreement with the Helsinki Declaration and all patients gave their informed consent. The study population comprised patients with temporomandibular disorder referred from the Pain Control Center of the University of Pernambuco from 2009 to 2010. The standardized examination/diagnosis procedure consisted of a questionnaire (Research Diagnostic Criteria for Temporomandibular Disorder; RDC/TMD [23]) which was individually fulfilled by potential patients. RDC/TMD is based on a set of operationalized clinical examination procedures and strict diagnostic criteria for the most common types of TMD [23]. It is comprised of a dual axis that facilitates a physical and a psychosocial approach to obtain information about TMD [23]. Because of these core characteristics, the RDC/TMD has been suggested as a powerful organizing structure for TMD research [24, 25]. In the 18 years since its introduction, the RDC/TMD has been used in a wide range of experimental, clinical, and population-based studies among adults and adolescents around the world [24].

Study design

Inclusion criteria were: male/female, no age limit, and myogenic TMD according to RDC/TMD (orofacial pain, tender points, limited jaw movements, and chewing difficulties). Exclusion criteria were: TMD subpopulations according to RDC/TMD (disk displacements with/without reduction, arthralgia, and osteoarthrosis), associated musculoskeletal or rheumatologic disease, insufficient number of natural or prosthetic incisors teeth to perform clinical measurements, LLLT clinical contra-indication conditions, and previous TMD treatment (e.g., surgical treatment, occlusal splint, low-level laser therapy). Patients were asked to stop taking analgesic or anti-inflammatory drugs 10 days immediately before the irradiation phase; otherwise, patient was excluded. TMD duration was recorded by the questionnaire and patients who did not answer the question "For how long have you been in pain or with discomfort during mastication?" were also excluded. According to individual answers, patients

Table 1 Patient's pain intensity among groups before and after treatment with LLLT

Group	Period	Pain intensity											
		No pain (VAS=0)		Mild pain (VAS=1–3)		Moderate pain (VAS=4–6)		Severe pain (VAS=7–9)		Worst pain (VAS=10)		Total	
		N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Acute TMD	Before	0	0	0	0	17	53.1	14	43.8	1	3.1	32	100
	After	11	34.4	21	65.6	0	0	0	0	0	0	32	100
Chronic TMD	Before	0	0	0	0	2	7.7	13	50	11	42.3	26	100
	After	0	0	2	7.7	20	76.9	4	15.4	0	0	26	100

VAS visual analog scale

were allocated into two groups, patients with acute TMD (less than 6 months) and chronic TMD (greater than or equal to 6 months). Both groups received the same low-level laser therapy protocol by the investigators (RFM, CECT, RKMG, and BHMR). For the irradiation and evaluation phases, the investigators were previously calibrated and unaware of which group the patient was allocated; therefore, this study was conducted in a double-blind fashion.

Low-level laser equipment and treatment protocol

The laser was calibrated before use and the laser probe was wiped with alcohol before each treatment. The patients and the investigator were required to wear protective glasses. The equipment was a gallium–aluminum–arsenide (GaAlAs) laser diode source (Thera Laser, DMC, São Carlos, SP, Brazil) with a wavelength of 830 nm and a continuous output beam of 40 mW. The laser delivers a spot of 6 mm (approximately diameter). All patients received the same treatment protocol according to Pinheiro et al. [9] and Carvalho et al. [26]. For each patient, 12 LLLT sessions were performed twice a week during 6 weeks. For each painful facial side, a laser light was delivered in continuous mode at five contact points around temporomandibular joint (TMJ) area: superior (S), inferior (I), anterior (A), posterior (P) and condyle (C). For the points S, I, A, and P, an energy density of 1.5 J/cm^2 per point was used (total of 6 J/cm^2) and for the point C an energy density of 2 J/cm^2 was used. The total amount of energy density was 8 J/cm^2. The time of laser application was automatically set by the laser equipment according to the dose selected, following the calibration of the manufacturer. The total amount of irradiation time per painful facial side was 60 s.

Clinical measurements

Pain intensity was measured during masticatory muscles palpation using a 10-cm visual analog scale (0–10, VAS) and it was categorized [7] using the following terms: no pain (0), mild (1–3), moderate (4–6), severe (7–9), or worst pain (10). To measure maximal mouth opening, patients were asked to open their mouths without assistance as wide as possible. Then, vertical distance from the incisal edge of the upper central incisor to the labioincisal edge of the opposing lower central incisor was recorded using a digital ruler (millimeters). Maximal mouth opening was categorized using the following terms: severe limited (≤29 mm), moderate limited (30–34 mm), limited (35–39 mm), and normal (≥40 mm).

Evaluation periods

One investigator (JALS-B), previously calibrated and blinded to the two groups, recorded all clinical measurements

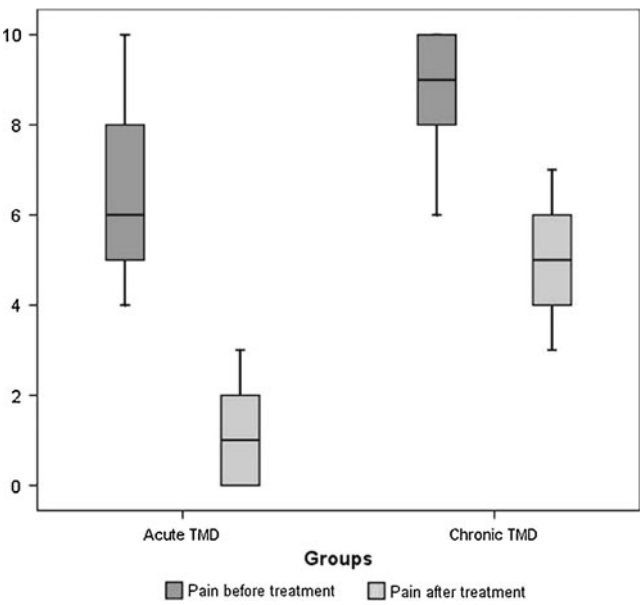

Fig. 1 Pain intensity measurements with visual analog scale before and after treatment with LLLT for the two groups, acute (n=32; Wilcoxon test, z=−4.962, p<0.001) and chronic TMD (n=26; Wilcoxon test, z=−4.495, p<0.001)

Table 2 Pain reduction among groups after treatment with LLLT

Group	Pain reduction									
	No reduction (Dif=0)		Mild reduction (Dif=1–2)		Moderate reduction (Dif=3–4)		Great reduction (Dif≥5)		Total	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%
Acute TMD	0	0	1	3.1	8	25	23	71.9	32	100
Chronic TMD	0	0	3	11.5	14	53.8	9	34.6	26	100

Dif difference of VAS measurement before minus after LLLT, *VAS* visual analog scale

(pain intensity and maximal mouth opening). The blind procedure was as follows: during experimental phase, patients were identified only as random numbers, and irradiation and evaluation periods were not done at the same moment. Thus, patients were evaluated (clinical measurements) by an investigator (JALS-B) before the first LLLT session and at the second day after the last LLLT session (12th session). The data were recorded and tabulated using spreadsheets (Excel 2007, Microsoft, USA).

Statistical analysis

Descriptive analysis of numerical, nominal and categorized variables was performed (absolute and percentage distributions, central tendency, dispersion). To perform inferential analysis, the Shapiro–Wilk test was used to determine normality and two nonparametric tests were used to compare the results before–after treatment (Wilcoxon test) and between the two groups (Mann–Whitney *U* test). The level of significance was 5% ($p < 0.05$). The statistical software used to do the calculations was Statistical Package for Social Science (SPSS 14.0, SPSS Inc, USA).

Results

Fifty-eight patients met all inclusion criteria, 32 in the acute TMD group (three male, 29 female) ranging from 20 to 84 years old (47.8±16.7, mean±SD) and 26 in the chronic TMD group (five male, 21 female) ranging from 19 to 86 years old (46.3±18.1, mean±SD). According to which side of the face was painful, 26 patients were irradiated unilaterally (16 acute TMD, 10 chronic TMD), whereas 32 were irradiated bilaterally (16 acute TMD, 16 chronic TMD). Of the 26 patients irradiated unilaterally, 10 patients had the left side irradiated (five patients in both groups) and 16 patients had the right side irradiated (11 acute TMD, five chronic TMD). During and after the irradiation patients were very receptive to LLLT and no negative side effects were reported.

Pain measurements before and after treatment

Table 1 summarizes the distribution of pain intensity reported by the patients among the groups before and after low-level laser therapy. Before treatment, all 58 patients (both groups) reported pain intensity ranging from moderate to worst pain. The mean pain intensity score before LLLT was 6 (ranging from 4 to 10) for acute TMD group and 9 (ranging from 6 to 10) for chronic TMD group. Therefore, 17 patients had moderate pain in acute TMD group and 13 had severe pain in the chronic TMD group, respectively. After therapy, all patients with acute TMD reported mean pain intensity score of 1 (ranging from 0 to 3), whereas all patients with chronic TMD reported pain intensity score of 5 (ranging from 3 to 7). Figure 1 shows a significant difference in the pain intensity reported by patients after treatment for each group, acute TMD (Wilcoxon test,

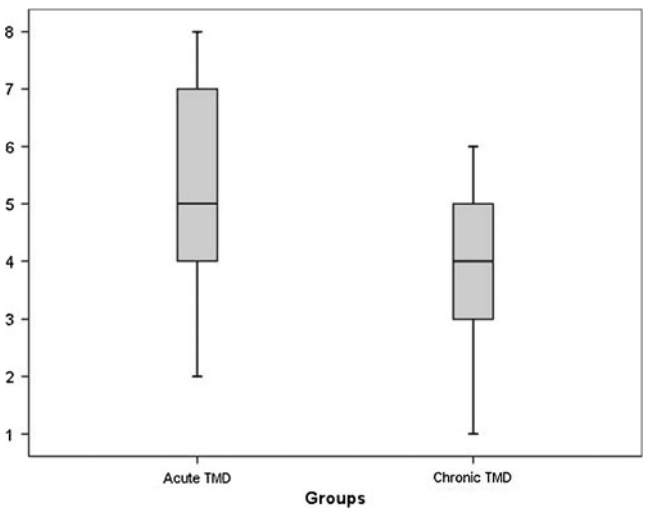

Fig. 2 Pain reduction after treatment with LLLT for the each group (Mann–Whitney *U* test; $z=-3.164$, $p=0.002$)

$z=-4.962$, $p<0.001$) and chronic TMD (Wilcoxon test, $z=-4.495$, $p<0.001$).

Pain intensity reduction

Table 2 summarizes the amount of pain reduction found among the groups after treatment with LLLT. All 58 patients had reduction in their pain intensity ranging from mild to great reduction. Patients with acute TMD had a mean pain reduction of 5 (ranging from 2 to 8), whereas patients with chronic TMD had a mean pain reduction of 4 (ranging from 1 to 6). Figure 2 shows a significant difference between pain intensity reduction in acute TMD patients, in comparison to patients with chronic TMD after low-level laser therapy (Mann–Whitney U test, $z=-3.164$, $p=0.002$).

Maximal mouth opening before and after treatment

The recorded maximal mouth opening, in millimeters, before and after low-level laser therapy is shown in Table 3. Before treatment, all 32 patients with acute TMD have shown maximal mouth openings ranging from moderated limited to limited (35.8±1.6, mean±SD), whereas patients with chronic TMD have shown maximal mouth openings ranging from severe limited to limited (32.5±3.2, mean±SD). After treatment, patients with acute TMD have shown maximal mouth opening ranging from moderated limited to normal (39.7±2.6, mean±SD), whereas patients with chronic TMD have shown maximal mouth opening ranging from severe limited to normal (34.9±4.0, mean±SD). Figure 3 shows a significant difference in the maximal mouth opening shown by patients after treatment for each group, acute TMD (Wilcoxon test, $z=-4.638$, $p<0.001$) and chronic TMD (Wilcoxon test, $z=-3.941$, $p<0.001$).

Maximal mouth opening improvement

The amount of maximal mouth opening improvement after LLLT is reported in Table 4. After LLLT, 28 acute TMD patients and 20 chronic TMD patients have shown a maximal mouth opening improvement ranging from mild improvement to improvement, whereas 10 patients (four acute TMD, six chronic TMD) have shown no maximal mouth opening improvement with the therapy. Figure 2 shows a significant difference between the maximal mouth opening improvements recorded in acute TMD patients, in comparison to patients with chronic TMD after low-level laser therapy (Mann–Whitney U test, $z=-2.557$, $p=0.011$)

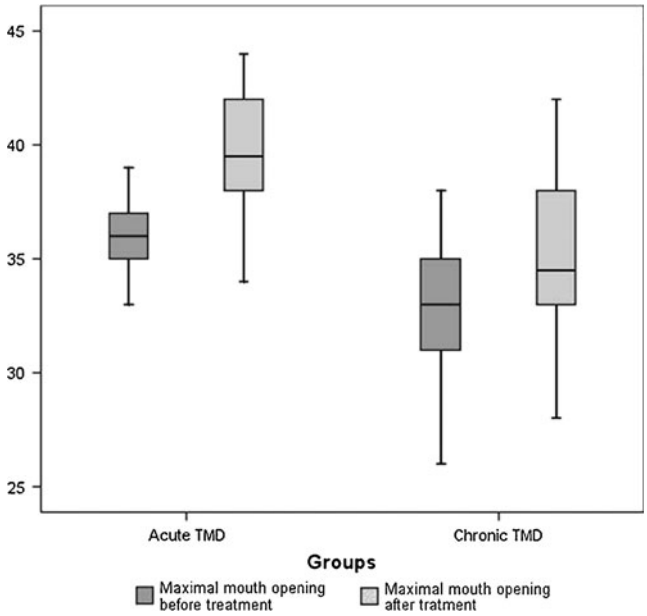

Fig. 3 Maximal mouth opening measurements in millimiters before and after treatment with LLLT for the two groups, acute ($n=32$; Wilcoxon test, $z=-4.962$, $p<0.001$) and chronic TMD ($n=26$; Wilcoxon test, $z=-4.495$, $p<0.001$)

Discussion

Low-level laser therapy is a noninvasive, rapid, and safe nonpharmaceutical treatment method that may be beneficial

Table 3 Patient's maximal mouth opening among groups before and after treatment with LLLT

Group	Period	Maximal mouth opening									
		Severe limited (MMO≤29)		Moderate limited (MMO=30–34)		Limited (MMO=35–39)		Normal (MMO≥40)		Total	
		N	%	*N*	%	*N*	%	*N*	%	*N*	%
Acute TMD	Before	0	0	6	18.8	26	81.3	0	0	32	100
	After	0	0	1	3.1	15	46.9	16	50	32	100
Chronic TMD	Before	5	19.2	14	53.8	7	26.9	0	0	26	100
	After	5	19.2	8	30.8	9	34.5	4	15.4	26	100

MMO maximal mouth opening in millimiters

Table 4 Maximal mouth improvement among groups after treatment with LLLT

Group	Maximal mouth opening improvement									
	No improvement (Dif=0)		Mild improvement (Dif=1–2)		Moderate improvement (Dif=3–4)		Improvement (Dif≥5)		Total	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%
Acute TMD	4	12.5	6	18.8	7	21.9	15	46.9	32	100
Chronic TMD	6	23.1	9	34.6	8	30.8	3	11.5	26	100

Dif difference of MMO measurement before minus after LLLT, *MMO* maximal mouth opening in millimiters

for patients with myogenic TMD. Thus, the purpose of this study was to evaluate whether low-level laser therapy could reduce pain intensity and improve maximal mouth opening of two temporomandibular disorders subpopulations, patients with acute (<6 months) and chronic (≥6 months) myogenic TMD (according to RDC/TMD). The results indicated that both subpopulations had significant pain intensity reduction and maximal mouth opening improvement after LLLT (Figs. 1 and 3); however, acute TMD patients showed more significant outcomes, in comparison to chronic TMD patients (Figs. 2 and 4). This positive result reinforces the biologic effects of laser therapy in the treatment of muscular and joint dysfunctions is due to its recognized analgesic effect, explained by the increase of beta endorphin level, increase of pain discharge threshold, decrease of bradykinin and histamine release, increase of lymphatic flow, decrease of edema and algesic substances, increase of blood supply, time reduction of inflammation, and promotion of muscle relaxation [10, 12]. Moreover, LLLT has a systemic effect, which may alter the sensorial input to patient's central nervous system and decrease the perception of pain [10].

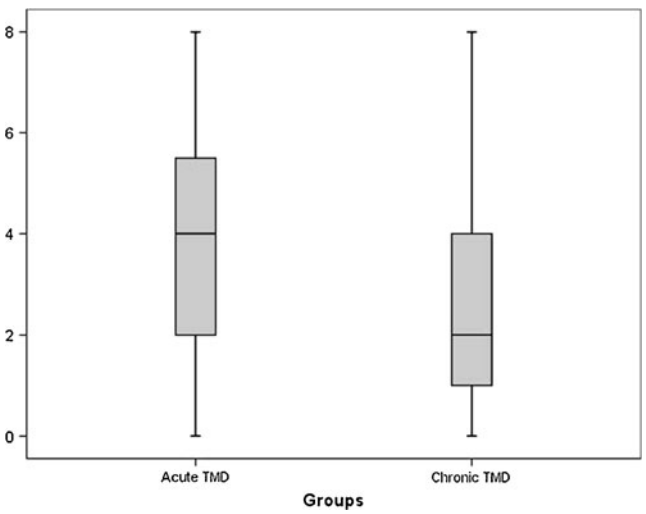

Fig. 4 Maximal mouth opening improvement after treatment with LLLT for the each group (Mann–Whitney *U* test, $z=-2.557$, $p=0.011$)

A considerable part of population present at least one sign or symptom of TMD, and the main complaint of patients with this dysfunction or the reason why they seek treatment is some type of joint or muscular pain [5, 27]. The typical clinical finding in patients with myogenic TMD is the tenderness or pain is referred to a location distant from its origins, and it is associated to a limited mouth opening due to pain [27]. In the current study, LLLT was applied on the selected points considering the presence of nociceptors in the TMJ area, because these structures are involved in the TMJ pain. Similar points in myogenic TMD patients were evaluated in other studies by some authors [9, 10, 12, 14, 26].

The TMD treatment using LLLT is evaluated in the literature in different ways, such as, LLLT versus placebo in arthrogenic and myogenic TMD [6, 8, 10, 12, 14, 15, 20, 22, 28], LLLT versus other physical therapies (transcutaneous electrical nerve stimulation [29] and microcurrent electrical neuromuscular stimulator [30]), and LLLT versus occlusal splints [31]. However, some results remain controversial [6, 10, 11, 15, 16, 21, 22]. In fact, some studies believe in pain relief, but not in physical improvement [8, 28]. Others found improvement in the amplitude of movements [12, 16, 20, 29]. In the current study, both pain intensity and maximal mouth opening improved after LLLT. Therefore, our results suggest that the effect of LLLT on the treatment of pain caused by TMD improved jaw mobility which it is also reported by other authors [12, 16, 29].

Three previous studies [7, 15, 16] sought to investigate LLLT outcomes for manager of acute and chronic TMD. From a methodological point, the current research is the first which was designed to specifically compare these two TMD subpopulations (acute and chronic TMD). Simunovic [7] investigated, in a case series, the laser irradiation of "trigger points", in different myofascial zones of particular sensibility, including temporomandibular joint (12 patients with facial pain), and reported that 79.04% of acute cases and 59.67% of chronic cases submitted to LLLT achieved 60% up to 100% of pain relief, respectively. In this study, the authors did not report the criteria for the diagnosis of facial pain. Emshoff et al. [15] assessed the effectiveness of LLLT

in the management of TMJ pain in a random and double-blind research design. The authors divided the sample into two groups (LLLT and placebo) with 26 patients each. The LLLT group had 12 acute and 14 chronic TMD patients, whereas the placebo group had 10 acute and 16 chronic TMD patients. Although, their results suggested that LLLT is not better than placebo at reducing TMJ pain during function, they did not report individual results for each TMD subpopulations, only an overall result. Fikackova et al. [16] compared the reduction in pain in patients with TMD treated with LLLT (10 or 15 J/cm^2) or sham laser (0.1 J/cm^2) and evaluated the therapeutic effect of LLLT in relation to TMD subgroups (arthrogenic and myogenic TMD) and duration of TMD-related pain (acute or chronic). The authors reported an improvement after laser therapy in 82% of patients with myofascial pain, 77% with TMJ arthralgia, and 73% with both myofascial pain and TMJ arthralgia. They concluded that LLLT was effective, especially for those with chronic pain. In the current study, we observed that acute TMD patients reported better results than chronic TMD patient.

The conflicting results found in the literature possibly occur because of the wide variation in therapy regimes employed, especially in terms of parameters such as wavelength, power output, and pulsing frequency. In addition, discrepancies in energy dosages, and therapy techniques and schedules may be important enough to complicate the evaluations. The differences in numbers and frequencies of treatment sessions, and the lack of standardized methods to assess TMD subpopulation may also increase heterogeneity in results [6]. Thus, it is difficult to compare the results of studies and the findings must be interpreted against each background.

In the current study, we used a gallium–aluminum–arsenide laser, which is known to penetrate to depths of 1–5 cm in soft tissue [6, 32]. This depth of penetration should be adequate to treat the temporomandibular joint, ligaments, and masticatory muscles [32] and different wavelengths of gallium–arsenide laser (660–670 nm [9, 22, 29], 780–790 nm [10, 11, 14, 26, 28], and 820–904 nm [6-9, 12, 16, 20, 22, 26, 30-32]) have been used or suggested for TMD treatment. However, clinical effectiveness (success or failure) depends on correctly applied adequate energy dose used gradually and regularly. Under and over-irradiation dosage may produce no effect or even opposite, negative effects, inhibitory effect [7]. In the current study, patients were very receptive to LLLT and no negative side effects were reported during and after the irradiation period.

Bjordal et al. [33] reviewed the effects of LLLT on acute pain and concluded that LLLT may modulate the inflammatory process in a dose-dependent manner and may also significantly reduce acute inflammatory pain. The authors assumed that doses of 0.4–19 J and energy densities of 5–21 mW/cm^2 would be capable of reducing inflammation at the target joint capsule without compromising fibroblast metabolism. Their study concluded that the optical parameters for the treatment of osteoarthritis, for infrared GaAlAs (λ830 nm), were 6–24 J per session and 3–210 mW/cm^2 of intensity. Other study suggests that recent clinical experience and clinical studies indicate that rather high doses are needed for myogenic conditions and that the energy density itself is of importance. Therefore, the authors suggest 6–10 J per point for myogenic conditions and 4–6 J per session for arthritis/arthrosis [22]. The dose in the current study was 8 J/cm^2 per session and this was congruent with previous studies [9, 33].

The promising results of the current study support previous findings that LLLT is an effective treatment for muscle pain that also improves maximal mouth opening. However, it does have some limitations. When evaluating a successful treatment of TMD, it is not easy to determine whether a decrease in pain is a real result of the treatment or a cyclic spontaneous remission of symptoms or a placebo effect [34]. This suggests a risk that our interpretations may be over- (or under-) statements. The investigators sought to control this risk using a double-blind design and allocating the subpopulations in two different groups.

In summary, considering the non-invasive and harmless characteristics of this modality, and the significant improvement obtained in both groups (acute and chronic TMD) in subjective parameters (e.g., pain), as well as, in objective functional parameters (e.g., maximal mouth opening), LLLT may promote some anti-inflammatory effect and pain relief in painful and dysfunctional temporomandibular muscles. Thus, LLLT could be use in the acute cases as monotherapy and in chronic cases as supplementary approach.

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