



The efficacy of low-level diode laser versus laser acupuncture for the treatment of myofascial pain dysfunction syndrome (MPDS)

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Background: Myofascial pain dysfunction syndrome (MPDS) is the most common type of temporomandibular disorder. This study compared the efficacies of low-level diode laser therapy (LLLT) and laser acupuncture therapy (LAT) in the treatment of MPDS.

Methods: This double-blind randomized controlled clinical trial included 24 patients with MPDS who were randomly divided into two equally sized groups. Patients in the LLLT group received 12 sessions of low-level diode laser irradiation applied to the trigger points of the masticatory muscles during 1 month. The same protocol was also used in the LAT group according to the specific trigger points. We measured pain intensity and maximum mouth opening in both groups at baseline, during treatment, and 2 months after treatment completion.

Results: The pain intensities decreased from 6.58 ± 1.31 to 0.33 ± 0.65 and from 7.08 ± 1.37 to 0 in the LLLT and LAT groups, respectively. The maximum mouth openings increased from 32.25 ± 8.78 mm to 42.58 ± 4.75 mm and from 33 ± 6.57 mm to 45.67 ± 3.86 mm in the LLLT and LAT groups, respectively. Pain intensity ($P = 0.839$) and level of maximum mouth opening ($P = 0.790$) did not differ significantly between the groups.

Conclusion: Our results showed similar efficacy between LLLT and LAT in the treatment of MPDS signs and symptoms.

Keywords: Acupuncture, Low-Level Light Therapy, Temporomandibular Joint Disorders.

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INTRODUCTION

Temporomandibular disorders (TMD) are a diverse group of pathologies involving the temporomandibular joint (TMJ), the muscles of mastication, and the supporting structures [1,2]. Epidemiologic studies have reported that 75% of the adult population has a minimum

of one sign of TMJ dysfunction, with approximately 30% of individuals showing more than one symptom [3]. TMDs are common in adults aged 20–50 years, with a higher frequency in females than in males [4]. The signs and symptoms of TMDs include pain in the TMJ and muscles of mastication [1,3]; articular sounds and crepitus [3]; joint locking [3]; headache; earache [3]; and mouth opening deviation, deflection, or restriction [1].

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TMD-associated pain is an important cause of disability, which imposes high socioeconomic burdens on patients [5]. Myofascial pain disorder syndrome (MPDS) is the most common form of TMDs affecting the muscles of mastication [6,7] and accounts for 90% of TMDs [8].

The various treatments for MPDS include soft diet, rest, moist heat, pharmacotherapy, ultrasound, massage therapy, transcutaneous electrical nerve stimulation (TENS), acupuncture, dry needling, and low-level laser therapy (LLLT) [9,10,11].

Among different physiotherapeutic methods for the treatment of MPDS, LLLT has gained popularity due to its conservativeness. LLLT has shown analgesic, healing, and anti-inflammatory effects on irradiated tissues. The mechanisms of action behind the therapeutic and analgesic effects are variable and include the release of endogenous opioids, enhancement of cellular respiration and tissue healing, vasodilation, increased pain threshold by changing the action potential of cell membranes, and decreasing inflammation by reducing prostaglandin E2 and cyclooxygenase 2 level [5].

Laser acupuncture therapy (LAT) is a therapeutic modality that uses laser light instead of a needle to stimulate acupuncture points [3]. This method has been used in the clinical setting since 1970 by using LLLT targeting the acupuncture points and some researchers have reported its optimal efficacy [12]. LAT is superior to conventional acupuncture since it is painless, atraumatic, non-invasive, and has a shorter duration. Moreover, LAT does not have any risk of infection and is ideal for patients with a fear of needles [13]. LAT has been suggested as an effective treatment modality to alleviate chronic pain associated with MPDS [14]. The mechanism of analgesic action of LAT has not been well elucidated; however, it may affect the synovia and stimulate cellular energy processes [14].

While Ahrari et al [15] and Maia et al [16] showed that LLLT improved MPDS, Huang et al [3] and Ferreira et al. [17] supported the therapeutic efficacy of LAT. However, no previous study compared the therapeutic and analgesic efficacy of LLLT and LAT for MPDS. As

acupuncture points are easier to find and access than trigger points and LAT requires fewer trigger points than those required for LLLT, this study aimed to compare the efficacy of LLLT and LAT for the treatment of MPDS.

METHODS

According to the results of a pilot study, we considered the expected average difference in pain intensity based on a visual analogue scale (VAS) between the two groups to be equal to 3 and the standard deviation of VAS to be equal to 2.5. To test and detect this difference with a type I error level of $\alpha = 0.05$ and type II error level of $\beta = 0.2$ (power = 80%), at least 11 samples were required in each of the treatment groups. The required sample size was calculated using PASS software. Thus, each treatment group in the current study included patients. The patients were assigned to each group using a table of randomized numbers in Excel software.

$$n = \frac{2(z_{1-\frac{\alpha}{2}} + z_{1-\beta})^2 s^2}{(\mu_1 - \mu_2)^2} :$$

This double-blind, single-center, randomized controlled clinical trial included 24 patients with MPDS presenting to the Oral Medicine Department of School of Dentistry at Shahid Beheshti University of Medical Sciences. The inclusion criteria were patients with: 1) MPDS who consented to participate in the study, 2) a minimum VAS pain score of 4 in their muscles of mastication, and 3) pain lasting for more than 3 months [17]. The exclusion criteria were patients 1) who were uncooperative, 2) with systemic diseases contraindicating laser therapy, and 3) under pharmaceutical therapy or other treatments for MPDS.

The study protocol was approved by the ethics committee of Shahid Beheshti University (code: IR.SBMU.IRDS.REC.1394.100) and registered in <http://www.irct.ir/> (code: IRCT2015102124631N1). The

Table 1. Laser irradiation protocol for the treatment of patients in the low-level diode laser therapy (LLLT) group

	1 st week	2 nd week	3 rd week	4 th week
Saturday	0.5 W	0.2 W	0.3 W	0.1 W
Sunday	0.4 W			
Monday	0.3 W	0.3 W		
Tuesday	0.2 W			
Wednesday	0.1 W	0.4 W	0.2 W	0.2 W

patients were briefed about the study and signed written informed consent forms before the beginning of the study. The patients were randomly divided into the LLLT and LAT groups (n = 12 each). The trained examiner and the patients were blinded to the group allocation (double-blind design).

The person who applied the laser irradiation was different from the person who evaluated the patients and completed the forms; thus, they were also blinded to the treatment modality. The patients were also unaware of which method of irradiation they had received.

The laser handpiece was calibrated before use at each radiation session and the laser probe was disinfected with alcohol before use for each patient. Both patients and operator wore protective glasses and laser irradiation was performed in a quiet room with adequate protective measures while the patient was seated on a dental chair in a comfortable position in such a way that the Frankfort plane (superior border of the external auditory meatus to the infraorbital rim) was parallel to the ground. The facial skin was cleaned with 70% alcohol before irradiation using a Ga-Al-As diode laser (Doctor Smile, Italy).

Laser irradiation

LLLT group: Patients in this group received 12 sessions of laser irradiation at 810 nm with the output powers indicated in Table 1 (irradiation protocol) in continuous mode using a probe with a diameter of 9 mm. The probe was positioned perpendicular to the irradiation site with slight pressure on the target muscle. Each masticatory muscle was examined by applying firm pressure bilaterally to find painful areas. The laser probe was then placed over the tender points identified in the first



Fig. 1. Laser irradiation of a tender point of the masseter muscle in the low-level diode laser therapy (LLLT) group.

treatment session with mild pressure and irradiation was applied (Fig. 1) for 60 seconds [5]. In this protocol, the number of irradiated points was equal to the number of involved muscles in each patient. As the power in each session differed, the power densities varied in each session but ranged between 6 and 24 J/cm².

LAT group: Patients in the LAT group received 12 sessions of laser irradiation once every other day for 4 weeks. The modified laser irradiation protocol was adopted as described by Hu et al (14). The ST6 and ST7 standard acupuncture points on the same side as the involved muscle and the LI4 point on the opposite side were irradiated with a laser wavelength of 810 nm, 150mW maximum power output, 5 W/cm² power density, and 7.5 and 26.25 J/cm² energy density for 5 seconds. The local Ashi point was irradiated for 40 seconds with the aforementioned parameters (Fig. 2). The acupuncture points were irradiated by a trained operator expert in identifying acupuncture points [14]. The LAT procedure used a tip 1 mm in diameter in contact mode.

At the beginning of each treatment session, the patient pain level was determined by a blinded examiner, who palpated the muscles of mastication, during which the patients expressed their level of pain using a 0–10 cm VAS (0: no pain, 10: maximum imaginable pain) [18]. To measure the pain-free maximum mandibular opening (MMO), the patients were requested to open their mouths as wide as possible until they felt pain. The vertical distance between edges of the upper and lower central



Fig. 2. Irradiation of acupuncture points in the laser acupuncture therapy (LAT) group. (A) Point LI4 on the opposite side and (B) point ST7 on the same side as the involved muscle.

Table 2. Underlying variables in the study participants

Variable	Type	No	Percentage%
Gender	Male	4	16.7
	female	20	83.3
occlusion	Class I	18	75
	Class II	4	16.7
	Class III	2	8.3
Para-function habit	Chewing gum	3	12.5
	Bruxism	9	37.5
	Clenching	13	54.1
	No para-function	8	33.3
Muscle involvement	Masseter	17	70.8
	Temporalis	9	37.5
	Medial pterygoid	16	66.6
	Lateral pterygoid	17	70.8

incisors was then measured in millimeters using a ruler.

According to Helkimo’s index, MMO is the pain-free maximum opening assessed by measuring the vertical distance between the edges of the upper and lower central incisors. This distance is normally 40 mm; values of 30–39 mm and < 30 mm indicated mild and indicate severe limitation, respectively [8].

Subjective pain severity, tenderness of muscle points, and pain-free MMO were measured at each session before laser irradiation and at 2 months after treatment completion. A minimum of 50% reduction in pain was defined as the recovery criterion [19].

The data were analyzed using IBM SPSS Statistics for Windows, version 21.0. Qualitative data were reported as absolute values and relative frequencies. Qualitative data were analyzed using chi-square and Fisher’s exact tests. Quantitative data were reported as means and

standard deviation. Repeated-measures analysis of variance (ANOVA) was used to analyze quantitative data. $P < 0.05$ was considered statistically significant.

RESULTS

Among the 24 patients, 20 (83.3%) were women and 4 (16.7%) were men. The sex distributions were the same in the LLLT and LAT groups.

The mean patient age was 41years (range, 24–59 years). The highest involvement was the masseter, with a mean VAS pain score of 7.57, followed by lateral pterygoid (mean pain score 6.85), temporalis (mean pain score: 6.66), and medial pterygoid (mean pain score: 6.25) muscles.

Table 2 shows the sex distribution, class of occlusion,

Table 3. Overall subjective pain and maximum mouth opening changes in patients

Changes group	Initial OSP ¹	Last session OSP	2 month follow up for OSP	Sig ² change in pain reduction	Pain relief session	Initial MMO ³	Last session MMO	2 month follow up for MMO	Sig change in MMO increase	Time of deletion of the MO ⁴ limitation
LLLT	6.58 ± 1.31	0.33 ± 0.65	0.33 ± 0.65	2 nd session	4 th session	32.25 ± 8.76	42.17 ± 4.58	42.58 ± 4.75	2 nd session	10 th session
LAT	7.08 ± 1.37	0.33 ± 0.77	0	2 nd session	4 th session	33 ± 6.57	43.25 ± 3.95	45.67 ± 3.86	3 rd session	11 th session

LAT, laser acupuncture therapy; LLLT, low-level diode laser therapy; MMO, maximum mouth opening; MO, mouth opening; OSP, overall subjective pain; Sig, significant.

Table 4. Changes in pain intensity in the involved muscles in the low-level diode laser therapy (LLLT) and laser acupuncture therapy (LAT) groups

Involved muscle	Group	Initial pain	Last session pain	2 month follow up pain	Significant change in pain reduction	Pain relief session
masseter	LLLT	7.57 ± 1.27	0.35 ± 0.62	0.35 ± 0.62	2 nd session	5 th session
	LAT	6.35 ± 2.42	0.10 ± 0.31	0	2 nd session	5 th session
temporalis	LLLT	6.66 ± 0.57	0	0	2 nd session	3 rd session
	LAT	5.25 ± 1.17	0.33 ± 0.81	0	3 rd session	5 th session
medial pterygoid	LLLT	6.25 ± 1.66	0.50 ± 0.54	0.5 ± 0.54	3 rd session	6 th session
	LAT	5.35 ± 2.58	0	0	2 nd session	4 th session
Lateral pterygoid	LLLT	6.85 ± 2.73	0.28 ± 0.48	0.28 ± 0.48	3 rd session	5 th session
	LAT	6.20 ± 2.61	0.20 ± 0.63	0.20 ± 0.63	3 rd session	4 th session

LAT, laser acupuncture therapy; LLLT, low-level diode laser therapy.

parafunctional habits, and muscle involvement of the patients.

Quantitative variables in LLLT and LAT groups

Subjective total pain score: The mean subjective total pain scores were 6.58 ± 1.31 in the first treatment session and 0.33 ± 0.65 at 2 months after the last session ($P < 0.0001$) in the LLLT group and 7.08 ± 1.38 in the first treatment session and 0 at 2 months after the last irradiation session in the LAT group ($P < 0.0001$).

Table 3 shows the pain scores of the patients at the baseline, the final treatment session, the follow-up, the trend of reduction in total subjective pain and time of recovery (defined as a minimum of 50% reduction in baseline pain score) in the LLLT and LAT groups.

The reduction in subjective total pain score did not differ significantly between the two groups ($P = 0.839$).

Pain-free MMO: The mean pain-free MMO was 32.62 mm (range 43–15 mm) in all patients ($n = 24$). The mean pain-free MMO was 32.25 ± 8.76 mm at baseline and 42.58 ± 4.75 mm at 2 months ($P = 0.001$) in the LLLT group and 33 ± 6.57 mm at baseline and 45.67 ± 3.86

mm at 2 months in the LAT group ($P < 0.0001$).

The mean MMO values at baseline, the final treatment session, and the follow-up session; increase in pain-free MMO; and complete recovery (no limitation in MMO) in the LLLT and LAT groups are shown in Table 3.

The time of significant increase in MMO did not differ significantly between the two groups ($P = 0.79$).

Changes in pain severity for each muscle of mastication: The changes in pain severity for each of the muscles of mastication were assessed as the mean pain score at baseline, the mean pain score at the final session, the mean pain score at 2 months, the time required for a significant reduction in pain, and the time required for recovery (defined as a minimum of 50% reduction in baseline pain score) separately for the masseter, temporalis, medial pterygoid and lateral pterygoid muscles in the LLLT and LAT groups (Table 4).

Comparisons of the efficacies of LLLT and LAT separately for each muscle of mastication showed no significant differences ($P = 0.258, 0.444, 0.253, \text{ and } 0.630$ for the masseter, temporalis, medial pterygoid, and lateral pterygoid muscles, respectively).

DISCUSSION

MPDS is one of the most common causes of orofacial pain. Patients often seek a dentist for problems other than toothache [8,20]. We observed a female predominance of MPDS, with a female to male ratio of 5:1, consistent with the findings of previous studies reporting a three to five-fold higher female than male patients [3,7,14,21]. This higher prevalence may be related to lower pain tolerance, more stressful lives, and higher rate of psychological disorders in this group of patients [14]. More than 60% of patients with MPDS in this study were aged 25–50 years, with a mean age at onset of 41 years. Similar findings were also reported in two different countries by Hue et al. and Manferedin et al. [14,22]. In terms of Angle's classification of malocclusion, Class I malocclusion was the most common type of occlusion in our patients with MPDS, followed by classes II and III. These findings were also in line with those reported by Mortazavi et al [8], Madani et al [23] Darbandi et al [24] Williamson et al [25], and Lauriti et al [26]. However, while some studies identified malocclusion as one of the most important etiologic factors in MPDS [27,28] other studies showed no or only mild relationships between TMD and malocclusion [29]. Parafunctional habits may play an etiologic role in MPDS, which can be explained as follows: long-term muscle contraction during bruxism prevents adequate blood supply to muscle tissue, resulting in the accumulation of CO₂ and pain-inducing products in the muscles. These processes eventually lead to pain, fatigue, and muscle spasm [8, 27-31]. Hu et al reported bruxism, clenching, and gum chewing as the most important pain-causing factors in the masseter and temporalis muscles [14]. In this study, clenching was the most common parafunctional habit in MPDS patients, followed by bruxism, and gum chewing. The same findings were also reported by Mortazavi et al [8]. Lauriti et al reported that about 30% of patients with MPDS had some type of parafunctional habit [26].

The frequency of muscle involvement and pain

intensity in patients with MPDS differs among individuals. We observed the highest involvement in the masseter and lateral pterygoid muscles and the lowest involvement in the temporalis muscle. The same results were reported by Sancakli et al and Khalighi et al [5,32]. Mortazavi et al observed the highest and the lowest frequencies of involvement in the medial pterygoid and temporalis muscles, respectively [8], while the lateral pterygoid was the most affected muscle in the study by Darbandi et al [24].

In this study, we observed notable reductions in pain for both treatment modalities (LAT and LLLT), with no statistically significant difference in pain management between groups. However, compared to LLLT, LAT had more stability in pain control in patients with MPDS (Table 3). Positive changes in MMO level and achievement of a normal level of pain-free MMO (40 mm) occurred earlier in the LLLT group compared to the LAT group. While MMO did not differ significantly between the LAT and LLLT groups, patients in the LAT had a greater MMO level than those in the LLLT group at 2 months after treatment (Table 3). No other studies have compared LLLT and LAT efficacy in the treatment of MPDS. However, Ahrari et al [15], Maia et al [16], Rohling et al [33], Mazzetto et al [34], and Kulekcioglu et al [35] reported the optimal efficacy of LLLT for pain management in TMDs. In contrast Cuhna et al [36], Emshoff et al [37], and Carrasco et al [38] reported that LLLT did not have a therapeutic effect in MPDS-related pain and dysfunction. While Huang et al [3], Ferreira et al [17], Ayyildiz et al [2], Hu et al [14], and Hotta et al. [12] demonstrated optimal efficacy of LAT in pain management of TMDs, Kannan et al [39] and Dunder et al [40] did not. These contrary findings may be related to differences in case selection methods, sample size, laser types, and irradiation protocols.

The results of the present study showed significant pain reduction in the masseter and lateral pterygoid muscles from the second and third sessions, respectively, in both groups. Recovery (> 50% reduction in pain score) in the masseter muscle started from the fifth session in both

groups, while that in the lateral pterygoid muscle started from the fifth and fourth sessions of LLLT and LAT, respectively.

Significant pain reduction in the temporalis muscle was achieved starting in the second and third sessions of LLLT and LAT, with recovery starting from the third and fifth sessions, respectively. Complete analgesia was achieved from the eighth session in the LLLT group and at 2 months following treatment completion in the LAT group. In the medial pterygoid muscle, the reduction in pain score reached statistical significance later in the LLLT group than in the LAT group. The same finding was also observed for the timing of recovery. Moreover, patients in the LAT group achieved complete analgesia at the final treatment session and pain had not recurred at the 2-month follow-up. However, our study was limited by the lack of a long-term follow-up.

In conclusion, the results of this study showed no significant differences in pain control and increased MMO between LLLT and LAT. However, the time required for the treatment of MPDS with LAT was shorter than that with LLLT and the trigger points in LAT are more accessible than those for LLLT.

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