Physical Therapy

Low-level laser therapy for management of TMJ osteoarthritis

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Aims: This study investigated the efficacy of low-level laser therapy (LLLT) for the management of temporomandibular joint (TMJ) osteoarthritis.

Methodology: In a double-blind clinical trial, 20 patients with TMJ osteoarthritis were randomly divided into laser and placebo groups. The patients in the laser group received irradiation from an 810 nm low-level laser (Peak power 80 W, average power 50 mW, 1500 Hz, 1 μs pulse width, 120 seconds, 6 J, 3.4 J/cm^2 per point), which was applied on four points around the TMJs and on painful muscles three times a week for 4 weeks. In the placebo group, the treatment was the same as that in the laser group, but with laser simulation. The patients were evaluated before laser therapy (T1), after 6 (T2) and 12 (T3) laser applications and 1 month after the last application (T4), and the amount of mouth opening and the pain intensity were recorded.

Results: No significant differences were found in mouth opening either between the study groups or between the different evaluation times in each group ($P>0.05$). There was no significant difference in pain symptoms of the masticatory muscles and TMJ between the laser and the placebo groups ($P>0.05$), but some significant within-group improvements were present for Visual Analogue Scale (VAS) scores of the body of the masseter and TMJ in both groups.

Conclusions: LLLT using the present laser parameters was no more effective than the placebo treatment for reducing pain and improving mouth opening in patients with TMJ osteoarthritis.

Keywords: Osteoarthritis, Temporomandibular joint, Temporomandibular disorder, Low-level laser, Low-intensity laser, Therapy, LLLT, LILT, TMD, TMJ

Introduction

Temporomandibular joint (TMJ) osteoarthritis or degenerative joint disease is a chronic joint disorder that affects the bony articular surfaces of the mandibular condyle and fossa. Osteoarthritis is generally associated with pain in the joint and often in the masticatory muscles, limited mandibular movements, and the presence of a grating joint sound (crepitation).[1] The degeneration and loss of articular cartilage has been considered the hallmark of joint osteoarthritis, which is accompanied with the characteristic feature of synovial inflammation.[2,3] Crepitation is a multiple grate-like sound and is most commonly observed in patients with osteoarthritic changes of the joint.[1] Occlusal appliances are considered the mainstay to treat TMJ osteoarthritis. However, these can be difficult to wear, and thus they are not popular among patients. The use of medications such as non-steroidal anti-inflammatory drugs is frequently associated with side effects such as gastric ulcer, counteracting their use in long-term applications.[4] Low-level laser therapy (LLLT) is one of the most recent physical therapy interventions that has been considered as a conservative, supportive therapy for the management of TMJ osteoarthritis; and because of its anti-inflammatory effect, LLLT may also be capable of attenuating the disease progress.

The mechanism underlying the therapeutic effects of low-level lasers is under debate. The analgesic effect of LLLT is well known and has been explained through different mechanisms.[5] Skinner *et al.* reported that application of a 904-nm laser produced significant stimulatory effects on fibroblast function and enhanced connective tissue repair.[6] Bjordal *et al.*[7] hypothesized that LLLT is efficient in inhibiting the

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inflammatory process in the irradiated joint capsule in a dose-dependent manner. Some authors suggested that LLLT can reduce inflammation through inhibition of PGE_2 formation and suppression of cyclooxygenase 2 in human gingival fibroblasts.[8] Carvalho *et al.*[9] reported that infrared laser therapy reduced inflammatory infiltration and accelerated the inflammation process in the rat TMJ injected by carrageen. Lin *et al.*[10,11] reported that HeNe laser (632.8 nm) improved histopathological changes and enhanced the repair and biosynthesis of arthritic cartilage in rats.

Previous studies reported pain relief,[12–23] reduction in chewing difficulty,[13] and increase in the range of mandibular movements[13,23–25] after application of low level lasers in patients with temporomandibular joint disorders (TMDs) of different etiology. However, there are some studies that demonstrated no significant superiority of laser therapy in reducing pain level[26–31] and enhancing functional movements,[26,32] compared to the placebo application. To date, few studies evaluated the effectiveness of LLLT in the management of TMJ osteoarthritis. In most of the studies found in the literature,[17,21,26,33–35] patients with TMJ problems were not specified to muscular, disc displacement, or articular entities, and the results were interpreted altogether. The present study, therefore, aimed to investigate the efficacy of LLLT, compared to the placebo application in the management of TMJ osteoarthritis, using the Visual Analogue Scale (VAS) for pain perception and measurement of mouth opening.

Materials and Methods

The study consisted of twenty patients with TMJ osteoarthritis attending the Department of Prosthodontics of Mashhad Dental School, Mashhad University of Medical Sciences, Mashhad, Iran. The patients had limited mandibular movements, and suffered from arthralgia (joint pain) and crepitation, especially in the late afternoon or evening. The diagnosis of osteoarthritis was made according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD),[36] and it was confirmed through the cone beam-computed tomography images taken from the TMJs, where evidence of structural changes at the condyle or fossa was diagnosed by an oral and maxillofacial radiologist. Subjects with TMDs resulting from muscular or disc displacement (with or without reduction) disorders, and those having any systemic disease affecting the TMJs were not included in the study. The exclusion criteria also comprised patients with psychiatric disorders and those undergoing any other form of therapy during the study period, such as analgesic or anti-inflammatory drugs, or occlusal splints. There were 19 women and 1 man, aged 35–60 years. The study protocol was approved by the Ethics Committee of Mashhad University of Medical Sciences, and it was registered in the US National Institutes of Health (NCT01417650). Each participant was informed about the procedures and signed a consent form before the commencement of the study.

Treatment regimens

The patients were randomly assigned into two groups of 10 each. Subjects in the laser group underwent active laser therapy, and those in the placebo group received placebo treatment. The laser device used in this study (Fig. 1) was a low-level laser emitting a pulsed infrared beam of 810 nm wavelength (Mustang 2000+, Moscow, Russia). The laser was applied in contact mode with a peak power of approximately 80 W, 50 mW average power at a pulse repetition rate of 1500 Hz, pulse length of 1 μs, 6 J per point, 3.4 J/cm^2, and spot size 1.76 cm^2, for 2 minutes per point. Painful muscles diagnosed at the first examination were irradiated, in addition to four points around the TMJs (posterior, anterior, and superior of the mandibular condyles, and inside the external auditory duct). The muscles included in the examination were the origin, body, and insertion of the masseter muscle; anterior, middle, and posterior parts of the body of the temporalis muscle; and insertion of the internal pterygoid muscle.[23] The total dose applied in each session varied between 27.2 and 60.8 J/cm^2, depending on the number of painful areas in each participant. The patients attended therapy three times a week for 4 weeks, totaling 12 sessions. The placebo group received the same treatment

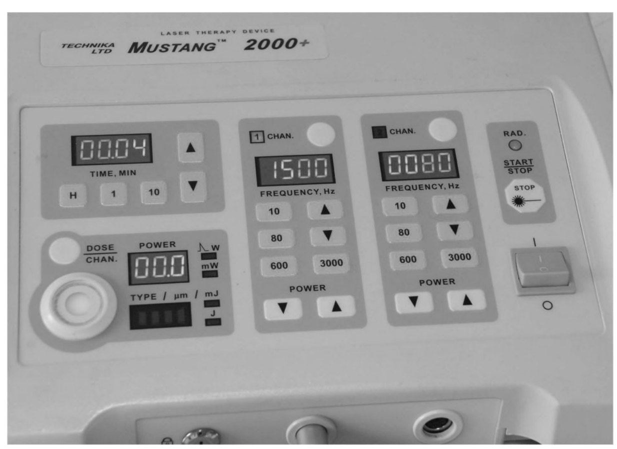

Figure 1 The laser apparatus used in this study (Mustang 2000+, Moscow, Russia) emitting at 810 nm.

protocol with the apparatus turned on, but without laser irradiation. The patients were not aware of the group to which they had been allocated. For safety reasons, both patient and laser therapist wore safety goggles during treatment. The output power of the laser apparatus was calibrated before the treatment and 3 months later, in order to assure yielding the desirable energy. Upon the completion of the study, subjects who were willing to continue therapy received another form of treatment for joint osteoarthritis.

Patient evaluation

The patients were evaluated before treatment (T1), after six sessions of laser therapy (T2), after 12 laser applications (T3), and 1 month after the last application (T4). At each evaluation, the maximum mouth opening was measured by a millimeter ruler, and the presence or absence of joint sounds was recorded. For perceiving joint sounds, the fingertips were placed over the lateral surfaces of the joint, and the patient was asked to open and close. The masticatory muscles and the TMJs (at rest and function) were also palpated bilaterally with firm and constant pressure. The VAS was used to quantify pain at palpation, and the patients were asked to mark the pain intensity on a 10-cm horizontal scale, where the left side indicated no pain (zero), and the right side (10) indicated the maximum pain possible. All evaluations were conducted by a blinded investigator who was not included in the study protocol and who had been instructed by a prosthodontist (AM) before starting the project, to achieve reliable pain measurements.

For statistical calculation, the VAS values (cm) obtained from masticatory muscles and TMJ were averaged between the right and the left sides. After confirming the normality of the data by the Kolmogorov–Smirnov test and the homogeneity of variances by the Levene's test, a repeated measures analysis of variance was used to determine any significant differences in the amount of mouth opening and pain intensity between the two groups and between the different time points in each group. The statistical calculation was performed by SPSS software (version 16.0; SPSS, Inc., Chicago, IL, USA), and the significance level was determined at $P<0.05$.

Results

All patients completed the study period. Figure 2 presents the changes in mouth opening values in the study groups over the course of the experiment. After 12 sessions of laser application, the mean mouth opening increased from 29.2 to 31.7 mm (8% improvement) for the laser group, and from 23.5 to 24.7 mm (5% improvement) for the placebo treatment. The statistical analysis revealed no significant difference either between the study groups or between the different evaluation times in each group ($P>0.05$).

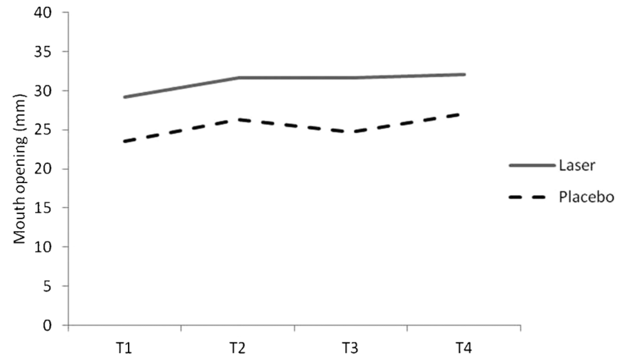

Figure 2 Line chart indicating the amount of mouth opening (mm) for the laser and placebo groups at different evaluation times.

The crepitation sound was present in subjects of both groups at all evaluations, and therefore, no reduction occurred in the number of subjects with joint sounds.

Table 1 presents the descriptive statistics regarding the VAS scores of the masticatory muscles for the two study groups. As shown in this table, both laser and placebo groups experienced a general improvement and an occasional worsening in VAS scores during the study period. Analyzing the data with repeated measures analysis revealed no significant difference in VAS scores of the masticatory muscles between the two groups ($P>0.05$), but some significant within group changes were observed. In the laser group, the significant differences were found between T1–T4 (39% improvement; $P=0.047$) and T2–T4 (42% improvement; $P=0.038$) for the body of the masseter muscle. In the placebo group, the significant differences were found between T1–T4 (53% improvement; $P=0.042$) and T2–T4 (35% improvement; $P=0.036$) for the body of the masseter muscle, and between T1–T2 (87% worsening; $P=0.037$) and T2–T4 (50% improvement; $P=0.019$) for the insertion of the masseter muscle.

The most severe pain location in both groups was observed in the TMJ during rest, and especially at function. Figures 3 and 4 represent variations of pain intensity in TMJ of patients in the experimental and control groups. After 12 sessions of laser therapy, the TMJ pain at rest showed 48% improvement in the laser group and 32% improvement in the placebo group compared to the initial examination, and there were 27% and 14% reduction in TMJ pain during function for the laser and placebo groups, respectively. The

Table 1 The descriptive statistics regarding the VAS scores (cm) of the masticatory muscles for the two study groups during the experiment

		T1		T2		T3		T4	
Variable	Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Origin of masseter	Laser	2.42	3.75	1.80	2.74	0.60	1.14	1.32	1.59
	Placebo	2.07	3.36	1.57	2.18	1.47	1.92	0.90	1.66
Body of masseter	Laser	2.45	3.12	2.57	3.45	1.57	2.39	1.50	2.12
	Placebo	4.00	2.74	2.88	2.22	2.30	1.31	1.87	1.78
Insertion of masseter	Laser	1.80	2.75	1.90	3.20	0.95	1.53	1.50	2.59
	Placebo	1.52	1.72	2.85	1.91	2.15	2.10	1.42	1.82
Anterior temporalis	Laser	1.93	2.44	2.05	3.32	0.75	1.58	1.40	2.66
	Placebo	1.80	2.29	1.75	2.12	1.05	1.80	1.30	1.98
Middle temporalis	Laser	1.80	3.15	0.70	1.63	0.50	1.15	1.27	1.90
	Placebo	1.35	1.79	2.05	2.49	0.96	1.11	0.80	1.02
Posterior temporalis	Laser	1.40	2.07	0.52	0.73	0.90	1.72	0.70	1.75
	Placebo	1.57	2.33	2.35	2.74	1.20	1.75	1.27	1.62
Insertion of internal pterygoid	Laser	3.95	3.06	3.05	1.90	2.82	2.01	2.75	2.50
	Placebo	5.17	3.61	4.52	3.02	4.30	2.93	3.55	3.41

repeated measures analysis revealed no significant difference in TMJ pain between the two groups at any of the treatment evaluations ($P>0.05$). However, the decrease in pain symptoms was significant between T1–T2, T1–T3, and T1–T4 in the laser group for both TMJ pain at rest and function ($P<0.05$). The statistically significant reduction in pain intensity was also observed in the placebo group between T1–T4, T2–T4, and T3–T4 for TMJ at rest and between T1–T4 and T3–T4 for TMJ at function ($P<0.05$).

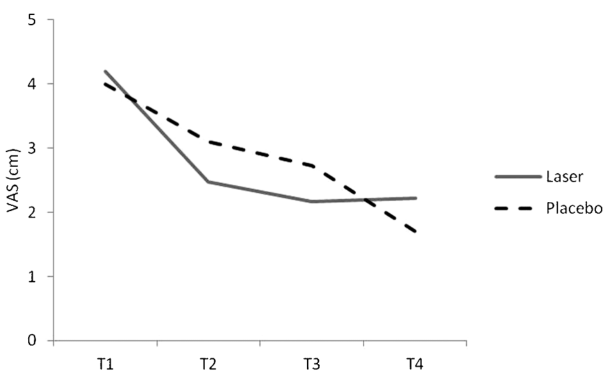

Figure 3 Line chart indicating VAS values (cm) of the TMJ at rest for the laser and placebo groups at different evaluation times. Significant differences were found between T1–T2, T1–T3, and T1–T4 in the laser group and between T1–T4, T2–T4, and T3–T4 in the placebo group.

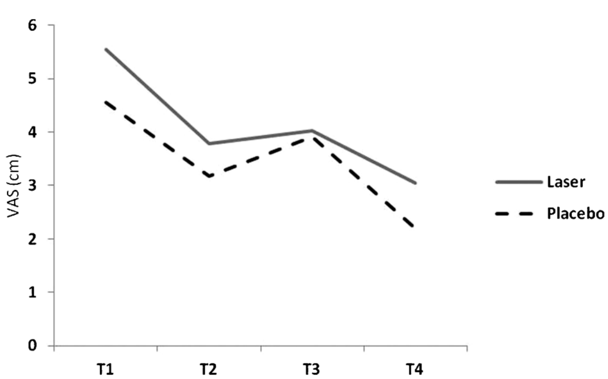

Figure 4 Line chart indicating VAS values (cm) of the TMJ at function for the laser and placebo groups at different evaluation times. Significant differences were found between T1–T2, T1–T3, and T1–T4 in the laser group and between T1–T4 and T3–T4 in the placebo group.

Discussion

This study investigated the effect of an 810-nm low-level laser on improving TMJ osteoarthritis. The inclusion criteria were designed so that patients with myogenic-originated TMDs and those with disc displacement were excluded from the study. The prevalence of women with TMJ osteoarthritis was disproportionately higher than men. The infrared laser used in this study has a penetration depth of about 2–3 cm (although dependent on application mode), enough to induce biological effects in the muscles and the TMJ.

For laser therapy in the TMJ, the authors selected four points located around the posterior, anterior, and superior parts of the mandibular condyle and inside the external auditory meatus. This is similar to the study of Carrasco *et al.*[12] who selected several points around the TMJ to irradiate a more extensive area of the joint. However, Bjordal *et al.*[7] believed that irradiation of a single point is capable of providing an optimal dose and inducing sufficient therapeutic effects in the TMJ affected with osteoarthritis. Mazzetto *et al.*[15] performed laser therapy at a point located inside the external auditory meatus toward the retrodiscal area, as they believed that pain receptors around periauricular tissues are responsible for codifying pain in the joint area.

In the present study, little improvement was observed in mouth opening values in either the laser or the placebo groups. After six sessions of laser therapy, mouth opening increased 2.4 mm in the laser group, and 2.8 mm in the placebo group, possibly due to the placebo effect of laser administration. At the end of the laser therapy and 1 month after the treatment, the laser group experienced a negligible improvement in mouth opening, but the placebo group showed a small decrease, followed by a small increase in mouth opening measurements. The comparison of mouth opening values between the experimental and control groups revealed no statistical difference, indicating that laser therapy within the parameters of this trial was not effective in promoting mandibular range of motion in subjects with TMJ osteoarthritis.

Joint sounds were present in all evaluation times in both groups, and no improvement was observed in this aspect. This is in agreement with the findings of Kulekcioglu *et al.*[24] who did not find any influence of laser therapy on the articular sounds in the study groups, which contradicts the study of Santos Tde *et al.*,[35] who reported a reduction in joint noise in 54.1% of the patients following LLLT. The crepitation sound in this study was perceived by placing fingertips over the lateral surfaces of the joint and asking the patient to open and close. A stethoscope or a joint sound recording device can be used to more carefully examine joint sounds compared to the palpation technique, but these devices may reveal many more sounds that are not clinically significant, and may result in undertaking inappropriate treatment.[1]

Regarding sensitivity to palpation of the masticatory muscles, a general improvement and occasional worsening occurred in pain symptoms of both groups after laser therapy, but the changes were small in most cases (Table 1). The improvement in pain intensity was significant for the body of the masseter muscle in both groups between T1–T4 and T2–T4 evaluations. In the placebo group, there was a significant worsening in pain symptoms for the insertion of the masseter muscle between T1–T2 time points, which was followed by a significant improvement between T2–T4 evaluations. The TMJs revealed the most severe pain location at the initial examination (T1). After laser and placebo treatment, some significant reduction in pain symptoms occurred for the TMJ at rest and function in both groups. The improvement observed in pain intensity of the laser and placebo groups can be attributed to the placebo effect of laser therapy, which has been reported in previous studies.[16,26,27] The interest of patients to be treated with a high technology laser apparatus has been assumed to produce a positive psychological effect, which influences the pain perception. Furthermore, TMJ problems are fluctuating with spontaneous remission of some acute symptoms, and are also self-limiting; thus, they may improve naturally without any intervention. It should be noted that the painful symptoms were not significantly different between the two groups either in the masticatory muscles or in the TMJ at any of the treatment evaluations. These results do not support LLLT, with the parameters of this trial, as a suitable treatment modality for TMJ osteoarthritis.

The findings of this study are similar to the outcomes of some previous authors who evaluated the efficacy of LLLT for improving osteoarthritis of other joints.[37,38] Conti *et al.*[39] found that the application of LLLT for TMD management was only effective in subjects with myogenous originated pain and had no influence on reducing pain of arthrogenous cases (830 nm, 4 J, three sessions). Kulekcioglu *et al.*,[24] on the other hand, found a significant improvement in mandibular functional movements and number of tender points in myogenic and arthrogenic cases treated with the active laser probe, but not for the placebo treatment (904 nm, 17 mW, 1000 Hz, 180 seconds, 3 J, 3 J/cm^2). Fikackova *et al.*[40] demonstrated the analgesic and anti-inflammatory effects of LLLT by infrared thermography in a case with arthralgia of the TMJ (830 nm, 400 mW, 4×15 J/cm^2 per session, 10 sessions). Hegedus *et al.*[41] concluded that LLLT decreased pain and improved microcirculation in patients with knee osteoarthritis (830 nm, 50 mW, 6 J per point, 48 J/cm^2 per session).

A major difficulty in evaluating the collected documentation is the variation in wavelength, dose, energy, and application modes. Furthermore, several papers lack full data on the applied energy (joules) and only state dose (J/cm^2). According to Bjordal *et al.*,[7] the energy density (J/cm^2, dose or fluence) delivered to the tissue is an important parameter to produce biological effects. However, the energy (J) is as important as the dose (J/cm^2), and the dose can easily become high by using a thin probe. If, for instance, the applied energy is 1 J and the size of the laser aperture is 1 cm^2, then the dose is 1 J/cm^2. However, if the size of the aperture is 0.25 cm^2, the dose becomes 4 J/cm^2. Thus, comparisons of J/cm^2 easily become irrelevant. For example, Brosseau *et al.*[37] reported that LLLT was not more effective than the placebo administration for decreasing pain, morning stiffness, and enhancing functional status in subjects with osteoarthritis of the hand. However, the dose and energies used have to be within a therapeutic window, and Brosseau *et al.*[37] applied 3 J/cm^2, but only 0.18 J per point and 8.8 J in total for an entire hand. The World Association for Laser Therapy (WALT) has issued dose recommendations and suggestions for the reporting of laser parameters. For the TMJ, the recommendation is 4 J in total, applied at 1–2 points (780–860 nm) or 2 J in total, applied at 2–3 points (904 nm).[42] The energy at the joint in the present study was 4×6 J$=$24 J, which could be over dosage, according to the WALT recommendations. For muscular conditions, WALT recommends 4–8 J per point, according to the thickness of the muscle.[42]

In this study, laser therapy was used with energy of 6 J and dose of 3.4 J/cm^2 per point. Although the dose was within the therapeutic window to produce biological effects in the target tissue, it did not produce desirable effects such as pain relief and increase of mouth opening in subjects with osteoarthritis of the TMJ. It may be that the total energy (24 J) was inhibitory in the joint area. It appears that more studies with greater sample size and with different energies and energy densities or other laser wavelengths should be performed to better determine the effect of laser therapy in managing patients with TMJ osteoarthritis. Comparison of other treatment modalities with laser therapy for treatment of TMJ osteoarthritis also needs further clarification. Patients affected with osteoarthritis of the TMJ often have complex problems, and it is possible that the symptoms would not be improved even with the application of other treatment modalities. The combined effect of LLLT with other physical therapies in the management of TMJ osteoarthritis should also be investigated in future studies. For the time being, the assumption that LLLT can reduce pain and inflammation in osteoarthritis of the TMJ mainly relies on *in vitro* and animal studies.

Conclusions

Under the conditions used in this study:

1. Both laser and placebo groups experienced negligible improvement in mouth opening over the period of the experiment, with no significant difference to each other.
2. There was no significant difference in pain intensity of the TMJ and masticatory muscles between the laser and placebo groups at any of the treatment evaluations. Some significant improvement, however, occurred in VAS scores of the masseter muscle and TMJ in both groups, which may be due to the placebo effect of laser administration.
3. With the laser parameters used in this study, LLLT was not superior over placebo application for improving pain and increasing mandibular movement in patients with TMJ osteoarthritis.

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