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ORIGINAL ARTICLE

Effectiveness of occlusal splints and low-level laser therapy on myofascial pain

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Abstract The present study was designed to 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). A total of 30 patients were selected after being diagnosed with MP according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TDM). The patients were divided into three groups. The first group was 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). LLLT (1,064 nm, 8 j/cm^2, 250 mW, Fotona) was applied to the patients in the study group once a day for 10 days, for a total of ten sessions. The same parameters and application times were used for placebo group, but the patients were not irradiated. The application was on the trigger points. The patients in the OS group were instructed to wear occlusal splints 12 h/day for 3 weeks. Functional examination was based on RDC/TDM, and pressure pain values were obtained with the Visual Analog Scale. Comparisons were made between the groups before and after the treatment according to Wilcoxon, Mann–Whitney U, and Kruskal–Wallis tests. The pain score values decreased significantly after both LLLT (p<0.05) and occlusal splint therapy (p<0.05) compared to placebo group (p<0.05). There was no significant difference between LLLT and OS groups after treatment (p>0.05). OS and LLLT are effective for decreasing MP. In addition, this particular type of LLLT is as effective as occlusal splint for pain relief.

Keywords Low-level laser therapy · Nd:YAG laser · Myofascial pain · Occlusal splint

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Introduction

The maxillomandibular unit is a unique system that performs vital functions, such as chewing, swallowing, and speaking. When there is an imbalance in this system, a wide range of clinical problems involving the orofacial muscles and joints arises. First, pain appears in the masticatory muscles and temporomandibular joint (TMJ) region, known as temporomandibular disorder (TMD) [1]. TMDs are multifactorial conditions in which the most prevalent clinical signs of TMD are pain in the joint and muscle, TMJ and muscle tenderness, TMJ sounds, limitation of mandibular movements or locking of the jaw, headache, and bruxism [2]. The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) divides TMD into three physical diagnostic categories: (i) masticatory muscle pain ("myofascial TMD," with or without limited jaw opening), (ii) TMJ disk displacement (reducing or non-reducing, with or without limited jaw opening), and (iii) other joint conditions (arthralgia, arthritis, arthrosis) [3, 4]. The pain associated with the multifactorial models of TMD is considered to be associated with a series of initiating, predisposing, and aggravating biomechanical, neuromuscular, biopsychosocial, and neurobiological factors. It is important to note that the pathophysiology and etiology of most craniofacial muscle pain conditions are far from being completely understood [5]. Myofascial pain (MP) can be considered the most common TMD and is the most frequent cause of persistent muscle pain. Spasms occur in a group of

muscles, but not a shortened muscle, as in myospasms. MP is characterized by pain originating from a group of muscles [6] that have some important points called muscle trigger points (TrPs) described as hyperirritable points located within the taut bands of skeletal muscles. TrPs are associated with a major source of musculoskeletal pain [7], and according to the most widely accepted pain theory, the pain associated with TrPs comes from a hypersensitive nodule in a taut band of skeletal muscle [8]. TrPs may be active (causes pain and may often cause general motor dysfunction) or latent (causes motor dysfunction without pain and is not sensitive to palpation) [8, 9]. Although the precise etiology and pathophysiology of MP (known as deep pain in the craniofacial region) are unknown, some possible important factors, such as microtrauma, macrotrauma (occlusal interferences, nocturnal bruxism, and physical overloading of the muscles), and systemic factors (psychiatric illness and emotional stress) have been identified [10]. This process also has a series of neurobiological mechanisms [5].

The etiology of TMD is multifactorial, and it may take many forms; therefore, the treatment of TMD is broad and varied [11]. The primary goal of local muscle pain treatment is to decrease sensory input to the central nervous system [12]. There are a lot of pharmacologic therapies, including injection of a local anesthetic or saline, botulinum toxin, nonsteroidal anti-inflammatory drugs (NSAIDs), antidepressants, benzodiazepine, tramadol, anticonvulsives, and α2-adrenergic agonists [13]. Non-pharmacologic therapies include occlusal splints, dry needling, physiotherapy and rehabilitation, ultrasound therapy, transcutaneous electrical nerve stimulation, relaxation techniques, acupuncture, stretching exercise, mesotherapy, massage therapy, low-level laser therapy (LLLT), and psychological treatment, among others [12, 14].

Low-level laser light application on tissues provides a clinical effect called biostimulation, where the basic mechanism occurs at the molecular level. Laser light penetrates through the tissue and strikes a chromophore or photosensitive molecule, which is the cytochrome contained within mitochondria. Adenosine diphosphate (ADP) is converted to adenosine triphosphate (ATP) by the mitochondrial cytochromes, thus supplying energy to the cell and driving cellular metabolism. In addition, biostimulation increases metabolism and cell replication in fibroblasts and endothelial cells [15].

It has also been demonstrated that analgesia is induced by LLLT, by stimulating the synthesis of endogenous endorphins (β-endorphin), decreasing the activity of C-fibers and bradykinin, and altering the pain threshold [16]. LLLT, an alternative pain relief therapy, has been used clinically for the treatment of musculoskeletal disorders and neurogenic pain, due to its analgesic, myorelaxant, tissue healing, anti-inflammatory, and biostimulation properties [6, 16–18]. LLLT has shown positive effects, with good patient acceptance and reduction in the use of drugs. There is no standardization of laser therapy protocol, such as laser application period, session interval, or laser dosages, so it is difficult to compare the results of LLLT studies [19].

The aims of the present study were to evaluate the effectiveness of occlusal splints and LLLT on MP and to compare the efficiency results of the two therapies.

Patients and methods

Experimental subjects

Seventy patients who applied to Gaziantep University, Department of Prosthodontics with a complaint of myofascial pain were preselected. All patients were examined by a single practitioner. Thirty patients fulfilled the eligibility criteria. The study included patients with combination of regional pain, reference pain pattern, presence of trigger points, and induction of pain with pressure on a trigger point as described by Carrasco et al. [6]. The exclusion criteria employed in this study was the same as established by Shirani et al. [20] in their study last 2009. Forty patients were excluded based on exclusion criteria (systemic diseases such as diabetes mellitus, epilepsy, heart disease, and pacemakers; intra-capsular disorders such as degenerative joint disease, rheumatoid arthritis, and psychiatric diseases; temporomandibular disorders with multiple active or latent trigger points; and disk displacement and ongoing treatment for TMD). Anamnesis forms were prepared, including all the pertinent information regarding the patients. The patients were informed about the therapy, and they signed written consent forms approved by Gaziantep University Human Subjects Research Review Committee. The patients were asked to report any pain during muscle palpations, and their answers were recorded according to the Visual Analog Scale (VAS). Provided that proper standardization methods are followed, approaches using pressure-pain thresholds are generally considered an improvement over manual muscle palpation [5]. There is good evidence that sensitivity to pressure stimuli has been proven to be a reliable and valid measurement method of local pain [5, 21]. The pressure with pain scores reported by the patients 15 days before treatment, on the last day of treatment, and 3 weeks after treatment ranged from 0 (no pain) to 10 (intense pain). The patients were divided into three groups (n=10): Group A, occlusal splint, Group B, LLLT, and Group C, placebo group.

Occlusal splint therapy (OST)

Stabilization splints were fabricated as described by Okeson [12], and additional adjustments were performed if necessary. The patients were instructed to wear the occlusal splints 12 h/

day for 3 weeks. The patients were called back for follow-up visits on day 21 (the last day of OST) and 3 weeks after the last day of OST. Data were collected 15 days before and 3 weeks after (42 days after insertion) the OST.

Laser irradiation

In the present study, laser wavelength and settings were adjusted as described by Usumez et al. [22, 23]. A neodymium-doped yttrium aluminum garnet laser (Nd:YAG;1,064 nm; Fidelis Plus III, Fotona; Ljubljana, Slovenia) was applied using a single-probe laser handpiece perpendicular to the surface, scanning the skin (Fig. 1). The beam angle was 90°, and the energy intensity applied to each muscle TrP was adjusted to 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. The dosage is calculated as power (W)/beam area (cm^2)×time (s)=J/cm^2.

The laser parameters (0.25 W, 20 s), the application times, handpiece, and the beam angle were similar for placebo and LLLT groups. For placebo group, the laser device was put to work and handpiece was applied to the skin perpendicularly without irradiation.

Statistical analysis

The data were analyzed with the SPSS 13 for Windows statistical program software. The level of significance was 5 % ($p<0.05$). There was a non-parametric distribution between the groups, so the data for the pretreatment pain values in the groups were analyzed with the Mann–Whitney *U* test. Pain decrease at the trigger points was analyzed according to the Wilcoxon test. Kruskal–Wallis test was used for analyzing each group in itself.

Results

The present study included 30 myofascial pain dysfunction syndrome (MPDS) patients, and 30 sets of data were analyzed. The sample size was restricted because of inclusion and exclusion criteria. The greatest pain levels were found on the masseter muscles. There was no restricted mouth opening. No statistical analysis of the patients' age, sex, education, or marital status was conducted. The mean VAS score differences and standard deviation between the groups are shown in Table 1.

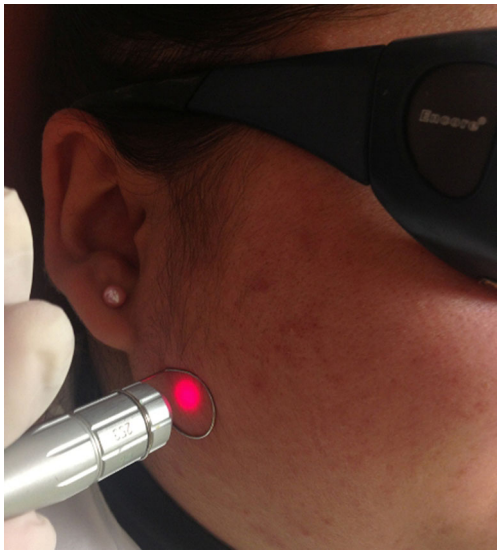

Fig. 1 Application of the LLLT to trigger point of the masseter

There were no statistically significant differences between pretreatment pain values between the groups according to the Mann–Whitney *U* test ($p=0.497$). There were statistically significant differences between before and after treatment pain values of group A ($p=0.005$) and group B ($p=0.005$) and no difference in group C ($p=0.109$) according to Kruskal–Wallis test. However, there was no statistically significant difference between after treatment VAS scores in the A and B groups ($p=0.491$). There were statistically significant differences in A and B groups compared to C group ($p=0.001$). The comparison of the VAS scores before treatment and pain decreasing after the treatment between the groups were analyzed by using Wilcoxon test (Fig. 2).

Discussion

This study was designed to investigate the clinical effects of LLLT applied directly to the palpable TrPs on myofascial muscles. The results demonstrated a reduction in pain levels for both groups when VAS was used as a subjective criterion. A significant reduction in pain scores was observed in both

Table 1 The mean difference standard deviation (SD) and *p* value of the VAS scores between evaluation times in the groups

Group	Evaluation period	Mean difference	SD	*p*
Group A	Before treatment	6.45	1.707	0.005
	After treatment	1.50	2.273	
Group B	Before treatment	6.60	1.506	0.005
	After treatment	2.00	2.309	
Group C	Before treatment	7.40	2.459	0.109
	After treatment	6.60	2.319	

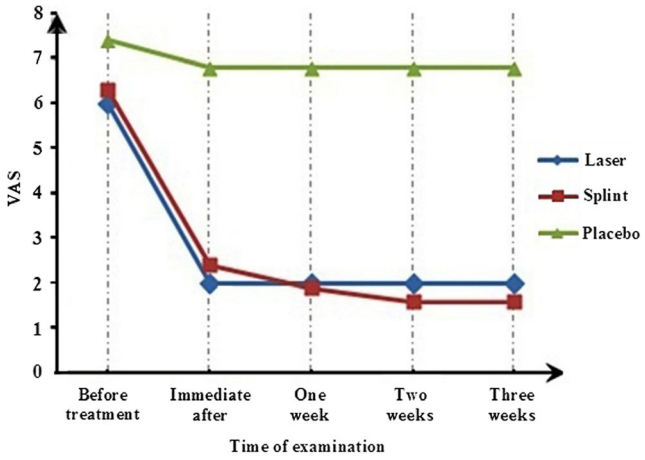

Fig. 2 The VAS mean scores at different evaluation times for the groups

groups after treatment. Because the pain scores on the last day of treatment and 15 days after treatment were the same, only the pain scores recorded 15 days before and 15 days after the treatment were evaluated.

The VAS was used as a subjective criterion for the evaluation of pain intensity. The American Dental Association (ADA) recommends that pain in the TMJ and mastication muscles be measured by palpating these structures and using a pain scale. The VAS has been used in other studies to measure pain on palpation at other points close to the joint region [24, 25].

The main mechanism of masticatory muscles fatigue, muscle weakness, and pain associated with TMD can explain the myalgia. There is decreased intramuscular blood flow caused by mechanical compression of the blood vessels and metabolite accumulation in myalgia. Circulatory disorders and/or inflammatory reactions in the synovial membrane of joints and tendons and the connective tissues of muscles and bones can cause pathological conditions in joints and muscles [26].

Several randomized and non-randomized, double-blind clinical studies have been carried out to investigate the effects of LLLT on TMD. The studies [1, 10, 17, 20, 27–30] reported that LLLT is an effective treatment for pain reduction in patients with TMD. Despite the fact that the precise mechanism of LLLT is not clear, it has a biostimulation effect [3, 15, 26, 28]. Biostimulation effects occur through metabolic activation, stimulation of the cellular respiratory chain in mitochondria, and increasing vascularization and fibroblast formation and oxygen supply to hypoxic cells in the painful areas. It also increases pressure pain thresholds, due to changes in cellular membrane potency, vasodilatation, and reduction of edema and through a complex electrolytic nerve fiber blocking mechanism, and it causes a decrease in the release of histamine and acetylcholine, as well as a reduction in the synthesis of bradykinin [15, 24, 26, 28, 29].

In the last 30 years, there has been growing interest in investigating the effects of LLLT and its various clinical applications in different medical specialties, as either a single or a complementary therapy [16]. However, there is no standardization for LLLT procedures regarding low-intensity laser type, dose, duration, wavelength, session, frequency, or evaluation period.

Different wavelengths, such as 808 nm GaAs [24], 830 nm GaAs [28, 29], 904 nm [31, 32], 780 nm GaAs [11, 25], 890 nm GaAs and 660 nm In–Ga–Al–P [20], and 830–904 nm Ga–Al–As [31], have been suggested as being effective in managing TMD. In the current study, a different wavelength (1,064 nm, Nd:YAG) was tested, and the results showed that it was an effective application during treatment of myofascial pain.

Another difference among the studies is energy density (dose). There is no precise evidence regarding the effective dose for myofascial pain in the literature; however, 6–10 J per session for myogenic conditions and 4–6 J per session for arthritis/arthrosis have been suggested [20]. In several studies supporting similar results, the dose and treatment methods were as follows: 6.2 J/cm^2+1 J/cm^2 in six sessions for painful muscles [20]; 5 J/cm^2 per point on the affected points (superior, anterior, posterior, and posterior–inferior to the lateral pole of the condyle) twice a week for 4 weeks [29]; and 3 J/cm^2 on the TrPs of each muscle twice a week, for a total of ten sessions [26]. In the present study, 8 J/cm^2 was applied precisely and continuously to the trigger points for 60 s, five times per week, for a total of ten sessions.

TMD is most often treated using occlusal splints safely to reduce TMJ load, and subsequently, clinical symptoms, as a reversible therapy [26, 27, 33]. Occlusal splints prepared according to Posselet's diagram eliminate the occlusal interference that occurs during protrusive and lateral movements [34]. In the present study, full-arch maxillary stabilization splints with canine guidance were used to provide an ideal removable occlusion and relaxed masticatory muscles.

The physiologic mechanisms of LLLT efficiency on significant decreasing musculoskeletal disorders pain are unknown [35]. The variable of VAS pain improved significantly in both groups A and B after treatment and showed beneficial changes compared with the placebo group. There was no any improvement for myofascial pain in placebo group.

One of the limitations of this study is that the evaluation times of the groups were different. While the LLLT group was evaluated 3 weeks after the last session, the OST group was evaluated 3 weeks after the end of the 3-week insertion time; as such, the LLLT duration was shorter than the OST. Another limitation is that pain perception is so subjective that the results almost depend on the patients' personal responses; in addition, pain threshold is variable as well.

Conclusion

It can be concluded that this particular type of LLLT (1,064 nm, 8 j/cm^2, 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.

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