Lasers Med Sci (2014) 29:29–35
DOI 10.1007/s10103-012-1228-7

ORIGINAL ARTICLE

Evaluation of low-level laser therapy effectiveness on the pain and masticatory performance of patients with myofascial pain

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Received: 12 September 2012 / Accepted: 29 October 2012 / Published online: 10 November 2012

Abstract This study investigated the effect of low-level laser therapy (LLLT) on the masticatory performance (MP), pressure pain threshold (PPT), and pain intensity in patients with myofascial pain. Twenty-one subjects, with myofascial pain according to Research Diagnostic Criteria/temporomandibular dysfunction, were divided into laser group (n=12) and placebo group (n=9) to receive laser therapy (active or placebo) two times per week for 4 weeks. The measured variables were: (1) MP by analysis of the geometric mean diameter (GMD) of the chewed particles using Optocal test material, (2) PPT by a pressure algometer, and (3) pain intensity by the visual analog scale (VAS). Measurements of MP and PPT were obtained at three time points: baseline, at the end of treatment with low-level laser and 30 days after (follow-up). VAS was measured at the same times as above and weekly throughout the laser therapy. The Friedman test was used at a significance level of 5 % for data analysis. The study was approved by the Ethics Committee of the Federal University of Sergipe (CAAE: 0025.0.107.000-10). A reduction in the GMD of crushed particles (p<0.01) and an increase in PPT (p<0.05) were seen only in the laser group when comparing the baseline and end-of-treatment values. Both groups showed a decrease in pain intensity at the end of treatment. LLLT promoted an improvement in MP and PPT of the masticatory muscles.

Keywords Laser therapy · Myofascial pain · Temporomandibular dysfunction · Masticatory performance · Pressure pain threshold

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Introduction

Musculoskeletal conditions and associated musculoskeletal pain have been considered as the causes of disability in the general population [1]. Temporomandibular dysfunction (TMD) is a type of musculoskeletal condition that collectively includes clinical problems involving the masticatory muscles, the temporomandibular joint (TMJ), and associated structures [2]. Among the TMDs, the most common is masticatory myofascial pain (MMP), which causes pain and limitation of function, especially in chewing.

Many treatment modalities have been described for the treatment of musculoskeletal disorders. In the case of TMD, the treatments available vary according to the involvement of muscle and joint structures, to the clinical signs and to the onset of the problem. The treatments of choice are usually conservative and reversible and involve education and counseling of the patients [3], cognitive behavioral therapy [4], pharmacotherapy [5], use of interocclusal devices [6] and physiotherapy [7], normally used in a combined way depending on the TMD diagnosis [8].

The use of low-level laser therapy (LLLT) has been seen as a complementary option for the treatment of TMD [5, 9, 10] due to its analgesic, anti-inflammatory action, and regenerative effects [11]. Moreover, it is a non-invasive therapy with few adverse effects [12], promoting a considerable degree of comfort to the patient moments after its application.

The treatment goal for patients with MMP aims to control pain and to recover masticatory function. The ways to assess the effectiveness of treatment may include subjective methods through self-report of pain by the patient and measured; objective methods, such as evaluation of pressure pain threshold (PPT) [13], and masticatory performance (MP) [14].

The results from the use of LLLT are controversial and show that they may be either higher [15] or equal to the placebo [16]. Moreover, little is known about the effectiveness of laser in relation to improved muscle function. To our knowledge, only one study has evaluated the efficacy of laser in MP; however, it used a sample of subjects with TMJ pain [15].

Accordingly, the present study's objective was to evaluate the effect of LLLT on muscle condition by measuring the PPT, analysis of MP and the perception of pain by individuals with MMP.

Materials and methods

Sample

A blind study was conducted with individuals having complaints of facial pain who sought treatment at the Department of Odontology, Federal University of Sergipe. The subjects were evaluated from March 2010 to November 2011 and their participation had to meet some criteria for inclusion, namely: (1) reporting pain in the facial region at a minimum intensity of 5 on the visual analog scale (VAS) with a duration of at least 3 months; (2) diagnosis of myofascial pain according to the Research Diagnostic Criteria for TMD Research Diagnostic Criteria (RDC)/TMD (axis I, categories Ia and Ib). This diagnosis was made by a systematically translated Brazilian version of the RDC/TMD (RDC/TMD axis I) [17]. In the present study, all RDC/TMD tests were performed by one examiner who was previously trained.

Excluded from the study were the following: (1) patients missing more than two posterior teeth (excluding third molars), presence of full denture or removable partial denture, presence of gross malocclusion (overbite and overjet greater than 6 mm, unilateral or anterior crossbite, or a discrepancy of centric relation to maximum intercuspation greater than 5 mm) [18]; (2) patients undergoing orthodontic treatment, medical treatment, or on medication for pain. All patients were instructed not to take nonsteroidal anti-inflammatory drugs or other analgesics during treatment and follow-up.

Subjects gave written consent to participate in the study. The study was conducted in accordance with the current good clinical practice guidelines and it was approved by the Ethics Committee of the Federal University of Sergipe (CAAE: 0025.0.107.000-10).

Study design

The study included 21 subjects, consisting of 19 females and two males, divided into two groups: the laser group (n=12) and the placebo group (n=9).

The subjects were evaluated by measuring MP, PPT, and pain intensity on three occasions: at the beginning (1 day before the start of laser therapy), at the end of treatment (eight sessions, twice weekly for 4 weeks), and 30 days after treatment with LLLT. In addition to these times, pain intensity was also measured weekly.

Assessment of masticatory performance

The tests were performed with a food simulant, called Optocal, containing the following components (by weight): 57 % silicone impression material Optosil Comfort® (Heraeus Kulzer, KG, Germany), 27 % toothpaste Sorriso® (Colgate Palmolive, SP, Brazil), 3 % solid vaseline (Rioquímica, SP, Brazil), 9 % dental plaster Exadur V® (Polidental Indústria e Comércio Ltda., SP, Brazil), 4 % alginate impression material Jeltrate Plus® (Dentsply Limited, Konstantz, Germany), and 1.08 g/40 g catalyst paste Profile® (Vigodent, RJ, Brazil)—a composition similar to that advocated by Slagter et al. [19]. The weight of each component of the mixture was measured on a digital balance accurate to 0.01 g (Micronal B-1600, Brazil), and, after mixing, the homogenized mass was placed in aluminum molds containing cylindrical compartments 10.0 mm in diameter × 6.0 mm in height, previously lubricated with vaseline, to produce rounded tablets. To ensure its complete hardening, the material was immediately stored in an oven at 65 °C for 16 h [19]. Then, the Optocal tablets were measured to a standardized weight (1.20–1.25 g) using a digital balance accurate to 0.01 g (Micronal B-1600, Brazil).

Before conducting the test, the subjects were trained in masticatory movement and the use of mouthwash, so that

only chewing and no swallowing happened. During testing, the subjects chewed the Optocal tablet with 20 movements, unilaterally or bilaterally, with the number controlled by the examiner. After each bite, all material was dispensed in a plastic container covered with a polyethylene filter strainer and the patient was asked to rinse the mouth twice. The rinse water was also collected with the chewed material, while ensuring the removal of any residue. Then, the collected material was filtered through a set of seven stacked sieves (Bertel Indústria Metalúrgica Ltda, SP, Brazil) with apertures of 5.6, 4.0, 2.8, 2.0, 1.4, 1.0, and 0.71 mm, coupled in descending order of aperture size, and placed on an agitator for 5 min. The particles retained on each sieve were weighed on an analytical balance.

Based on the weight of the Optocal retained on each sieve, the geometric mean diameter (GMD) of the ground particles was calculated using the weighted geometric mean proposed by Mendonça et al. [20] using Excel spreadsheets (Microsoft). The GMD represents the index of performance/chewing efficiency, with a lower value obtained from a smaller GMD, indicating better MP [20].

Assessment of pain

PPT [13] was measured using an analog compression dynamometer (Crown® Dynamometer-AT 04114, SP, Brazil) with a 1 cm^2 end and at an application rate of 0.5 kg/s. Volunteers were asked to report when the sensation of pressure changed to pain; this point indicated the PPT value. The PPT was measured bilaterally for the anterior temporal and masseter muscles. Two measurements were performed for each muscle, and the obtained mean was the value considered. PPT value was recorded as kilograms per square centimeter.

Pain intensity was measured by VAS [21]. On a straight line of 10 cm, which represents continuous pain, with the left end representing no pain and the right end representing the worst pain imaginable, the patients were instructed to choose the point that best determined the intensity of their spontaneous pain. The observer measured, in centimeters, the distance between the end representing no pain and the mark made by the patient, which corresponds to the intensity of their pain.

Laser irradiation parameters

The PhotonLase III, a GaAlAs semiconductor diode laser (DMC Equipmentos®, São Carlos, SP, Brazil), was used as the LLLT device, after evaluation and calibration by the manufacturer. At the trigger points of the anterior temporal and masseter muscles (previously noted in the clinical assessment), five points were applied on each muscle, four forming a cross and one a central point. The LLLT was applied in the continuous emission mode and in the point application mode, with the pen perpendicular to the irradiated area; the frequency was two times per week for 1 month, for a total of eight sessions. During the sessions, all patients were instructed to wear safety goggles.

Irradiation parameters were as follows: wavelength=808 nm (infrared), laser optical power=100 mW, spot area=0.028 cm^2, distance between the points of application=1 cm, total energy=1.9 J, energy density=70 J/cm^2, and time per point=19 s.

For the placebo group, the apparatus was programmed to be used in the red wavelength (660 nm), with the pen tip covered by its own storage protector shield during the entire treatment, preventing the laser light output. Thus, an infrared pen was used on the patient to simulate the application of laser therapy with nothing emitted. The advantage of this procedure is that the device remains on and emitting the same audible alerts that it normally emits every 10 s, reproducing greater

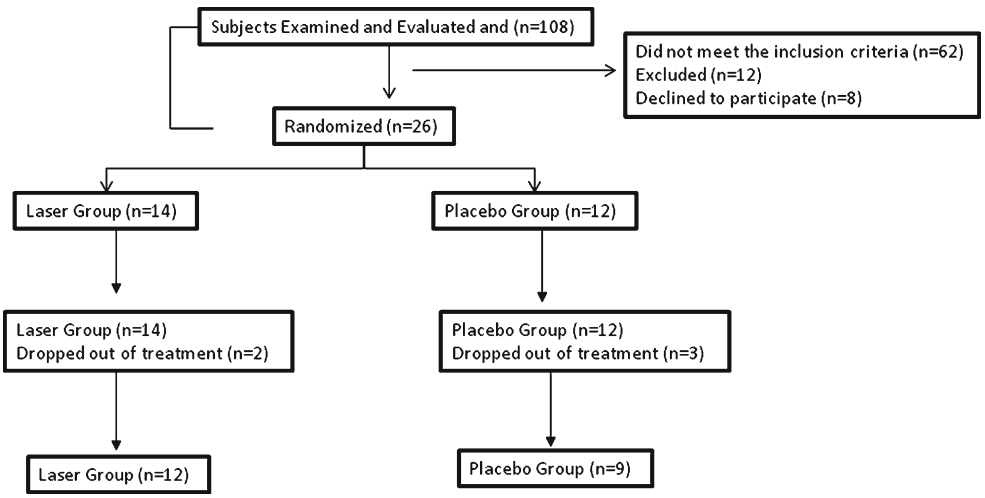

Fig. 1 Flowchart of patient progress through all phases of treatment

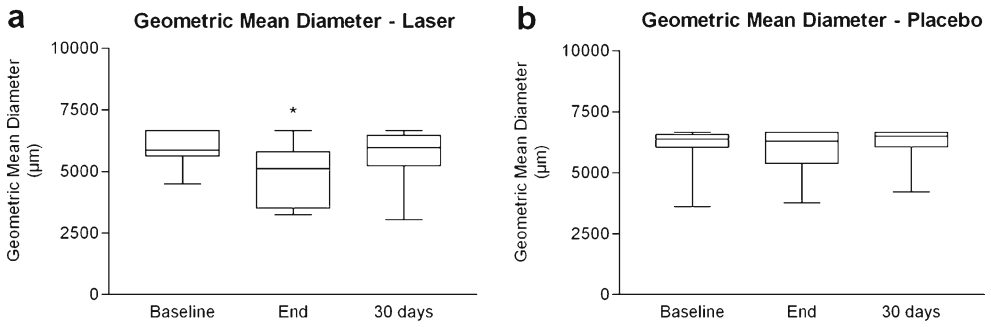

Fig. 2 Median of the geometric mean diameter of the crushed test food at the following times: baseline, end of treatment and 30 days after treatment for the laser (**a**) and placebo (**b**) groups. *Square* interquartile range, *horizontal line* median, and *error bar* minimum and maximum values. *Asterisk* indicates a significant difference compared to baseline (Friedman test followed by Dunn's post test)

accuracy in the treatment. Furthermore, the preparation and protection of the patient followed the same parameters used in the test group.

Statistical analysis

The data were expressed as median and interquartile ranges. For intra-group comparison of median values of masticatory efficiency, PPT and pain intensity, the Friedman test was used followed by Dunn's post test. The comparison of baseline values between groups was performed using Mann–Whitney test. For all tests, a significance level of 5 % was considered.

Results

Women accounted for 90.5 % of the total sample, whose mean age was 27.76±10.44. Most subjects had a high school degree (85.71 %) and were single (57.15 %).

Of the subjects 108 were evaluated, of which only 26 were able to participate in the study. These were randomly divided into two groups: laser group (n=14) and placebo group (n=12). Twelve subjects from the laser group and nine from the placebo group completed all phases of the study (Fig. 1). The reasons for exclusion or withdrawal from the study are described in Fig. 1.

No significant differences were found for baseline values between groups for all the evaluated parameters, except for pain intensity measured by VAS (p=0.04), in that the laser group values were higher than placebo group values.

The GMD median values of the chewed Optocal particles for the laser and placebo groups are described in Fig. 2. There was a significant reduction in GMD only for the laser group at the end of treatment compared with baseline values (p<0.01).

The PPT median values for the anterior temporal and masseter muscles are shown in Figs. 3 and 4, respectively. The laser group showed an increase in masseter PPT at the end of treatment (p<0.01), which remained for 30 days after treatment (p<0.05). For the temporal muscle, this increase occurred only at the end of treatment (p<0.05). The placebo group did not show a change in PPT values for the temporal and masseter muscles.

The pain intensity reported by patients from both groups is described in Fig. 5. A reduction in pain intensity was observed in both groups when comparing baseline and end-of-treatment values (laser group, p<0.001; placebo group, p <0.01). At 30 days after treatment, this reduction continued only for the laser group (p<0.001).

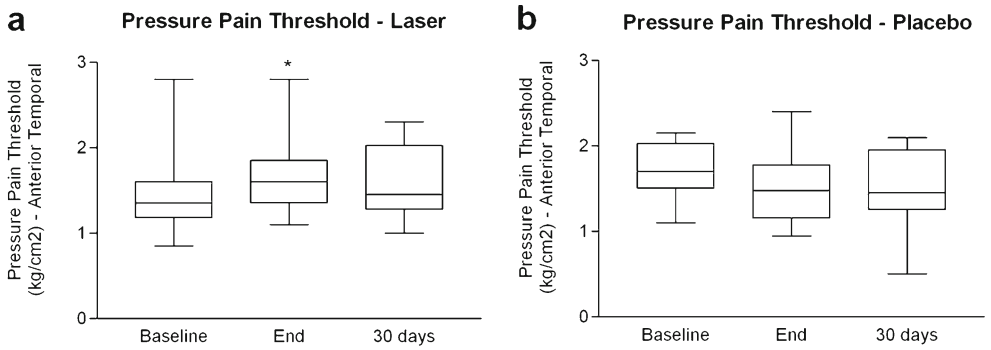

Fig. 3 Median of the pressure pain threshold for the temporal muscle at the following times: baseline, end of treatment and 30 days after treatment for the laser (**a**) and placebo (**b**) groups. *Square* interquartile range, *horizontal line* median, and *error bar* minimum and maximum values. *Asterisks* indicates a significant difference compared to baseline (Friedman test followed by Dunn's post test)

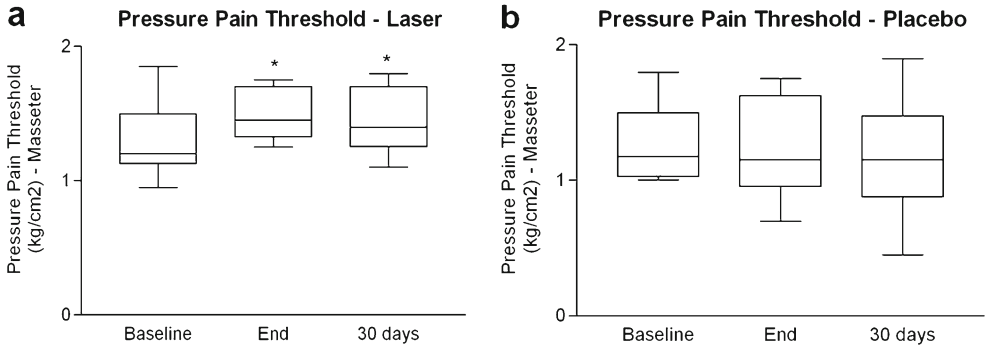

Fig. 4 Median of the pressure pain threshold for the masseter muscle at the following times: baseline, end of treatment and 30 days after treatment for the laser (**a**) and placebo (**b**) groups. *Square* interquartile range, *horizontal line* median, and *error bar* minimum and maximum values. *Asterisk* indicates a significant difference compared to baseline (Friedman test followed by Dunn's post test)

Discussion

The main findings of this study were: (1) improvement in masticatory efficiency in the laser group, (2) increase in masticatory muscle PPT in the laser group and (3) reduction in pain intensity reported by patients from both groups.

Mastication is one of the main functions of the stomatognathic system and can be compromised by the presence of painful conditions, such as myofascial pain [22, 23]. Limitation of masticatory function is one of the problems encountered in patients with TMD [24]. Thus, methods that promote an improvement of this function should be part of treatment. Few studies have investigated the effect of laser therapy in the improvement of masticatory activity in patients with myofascial pain. One of the main findings of this study was that LLLT improves MP in this population. Data on the effectiveness of LLLT on the performance of the masticatory muscles are scarce, but positive effects have been reported for other muscle groups [25]. The use of laser therapy resulted in functional improvement of the cervical muscles in patients with chronic myofascial pain in the neck [26]. In this study, an increase of MP was observed only in the laser group, which emphasizes the role of LLLT in improving muscle function.

The MP assessment method used in the present study is reliable and easy to apply [20]. The results of this study, in relation to masticatory efficiency, were different from those observed by Carrasco et al. [15] who employed another method for assessing MP (colorimetric) using patients with joint pain and not muscle pain, as used in this study [15].

The measurement of PPT is a tool used mainly in studies that diagnose and evaluate treatment efficacy with respect to pain [27]. High PPT values are associated with asymptomatic individuals, while low values are present in individuals who suffer from painful muscle conditions related to phenomena of peripheral sensitization and increased excitability of the nociceptors [27, 28]. In this study, the use of LLLT increased the PPT of the masticatory muscles in the Laser Group, which corroborates previous studies [29]. Laser therapy promotes a reduction of the components responsible for muscle pain and peripheral sensitization through increased local blood circulation due to neoangiogenesis, and reduction in inflammatory intensity due to its action in cells that participate directly in remission, as well as by inhibiting the synthesis of chemical mediators inherent to inflammation, such as PGE [30]. It is also suggested that laser therapy improves blood supply, promotes an increase

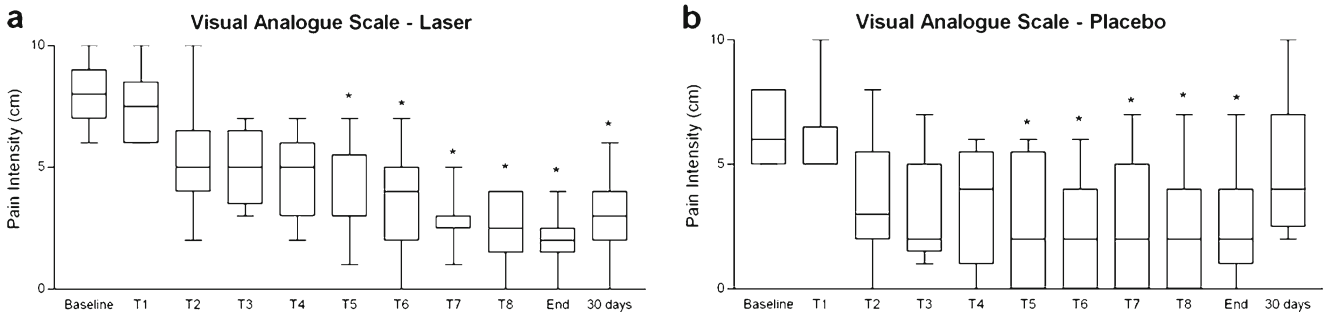

Fig. 5 Median of pain intensity reported at the following times: baseline, T1–T8, end of treatment, and 30 days after treatment for the laser (**a**) and placebo (**b**) groups. *Square* interquartile range, *horizontal line* median, and *error bar* minimum and maximum values. *Asterisk* indicates a significant difference compared to baseline (Friedman test followed by Dunn's post test). *T1.....T8* evaluation of pain intensity conducted during each application session of activated laser or placebo

in muscle oxygen and rebalances the pH, which contribute to the improvement in pain, as hypoxic conditions and low pH can generate nociceptive impulses [31].

The subjective improvement in pain intensity, measured by VAS, was not influenced by LLLT, as it occurred for both the laser and placebo groups, while the measurements of PPT and masticatory efficiency were higher in the laser group.

The evaluation of pain intensity is probably the most commonly measured dimension [31]. One of the most common ways to obtain this measurement is by the VAS. Although the VAS is widely used in research and in the clinical setting for subjective evaluation of pain and the effect of therapy, there is a risk of over- or underestimating the pain reported by patients when these data are consolidated [32]. In addition, there are factors that can contribute and influence the perception of pain by the patient, including previous experiences, psychological factors (e.g., depression, anxiety, dependence) and sociodemographics (e.g., types of work, educational level, marital status) [33].

This similar reduction in pain perception between the groups may be due to a placebo effect. It has been proposed that placebo analgesia could activate endogenous opioids [34] and neural mechanisms of pain modulation [35, 36], and such effects may have contributed to the improvement of pain perception in both groups. The use of a technological tool, such as the devices used in this study, may also have influenced the occurrence and magnitude of this effect.

Similar results were reported for other muscle groups [25, 37]. These differences may be explained by the fact that pain reported by patients using the VAS records the general perception of pain, and that is the result of a complex combination of different factors [38], as described above. The fact that measurement of PPT and masticatory efficiency reflect more objective parameters in the evaluation by considering a specific location (masticatory muscles) [17, 20] may explain the difference in findings for PPT and masticatory efficiency with respect to pain intensity reported by the patient.

There was a regression in masticatory efficiency and PPT 30 days after the end of treatment. This shows that LLLT has a strong immediate effect, especially in improving muscle condition, which is corroborated by other studies that found that LLLT reduces the markers of tissue damage [37]. It is tempting to speculate that a treatment with more than eight sessions could lead to longer-lasting results; however, further studies are necessary to verify this hypothesis.

When considering that the study subjects suffered from pain for at least 3 months, it is plausible to infer the existence of central sensitization processes that may have contributed to the persistence of a painful syndrome [39]. These changes in the nervous system can be initiated and influenced by nociceptive afferents [40]. Therefore, decreasing the number of peripheral impulses, which is one of the principal mechanisms of action of LLLT [41], helps to mitigate the effects of central sensitization with a consequent reduction in pain and improved function, as noted in this study.

Accordingly, we suggest the indication of laser therapy as an adjunct in the treatment of myofascial pain, especially for clinical symptoms accompanied by worsening of masticatory function.

Conclusions

Based on the foregoing, it can be concluded that LLLT improves the MP and PPT of the masticatory muscles; however, this effect weakens after discontinuation of therapy..

Acknowledgments We would to thank to Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the finnancial support.

Conflict of interest The authors declare that they have no conflict of interest.

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