ISSN 1413-3555
Rev Bras Fisioter, São Carlos, v. 12, n. 1, p. 37-42, jan./fev. 2008
©Revista Brasileira de Fisioterapia

Clinical analysis of the effect of laser photobiomodulation (GaAs – 904 nm) on temporomandibular joint dysfunction

Análise clínica do efeito da fotobiomodulação laser (GaAs – 904 nm) sobre a disfunção temporomandibular

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Abstract

Introduction: Over the last few years, there has been great interest in studying new methods for treating temporomandibular joint dysfunction (TMD). Pain, described as facial pain, headache or earache, usually exacerbated by jaw use, is generally the patients' main complaint. Laser photobiomodulation has been used for treating pain in cases of TMD. **Objective:** The aim of this study was to investigate the pain levels in TMD patients treated with laser photobiomodulation. **Material and methods:** Eighteen female patients of mean age was 27 years (± 7), with a diagnosis of TMD, were studied. They were randomly divided into two groups: Placebo (Control) and Experimental Groups. The Experimental Group (n= 10) received treatment twice a week, for four consecutive weeks (totaling eight applications). The GaAs laser (904 nm) was used, with 6 J/cm^2, 0.38 mW/cm^2, beam area of 0.039cm^2 and continuous emission mode. The laser was applied at four pre-auricular points and one in the external auditory meatus. The Placebo Group (n= 8) was manipulated in the same way as the treated group, but with the laser switched off. To analyze the patients' pain levels, a visual analog scale (VAS) was used, before and after the therapy. To analyze the data, Student's *t* test was used, with a significance level of 5% (p< 0.05). **Results:** A significant reduction (p< 0.05) in the pain level was observed in the Treated Group. **Conclusions:** The tested laser photobiomodulation (GaAs, 904 nm) demonstrated positive results regarding the relief of painful symptoms in patients with TMD.

Key words: temporomandibular joint; laser photobiomodulation; pain.

Resumo

Introdução: Nos últimos anos, tem sido notado grande interesse no estudo de novas modalidades para o tratamento das disfunções temporomandibulares (DTM). A dor descrita como dor facial, cefaléia ou dor de ouvido, comumente exacerbada pela função da mandíbula, é, em geral, a principal queixa do paciente. A fotobiomodulação laser vem sendo utilizada no tratamento da dor em DTM. **Objetivo:** O objetivo deste estudo foi verificar o nível de dor de pacientes com DTM tratados com fotobiomodulação laser. **Materiais e métodos:** Foram estudados 18 pacientes do sexo feminino, com idade média de 27 anos (± 7), com diagnóstico de DTM, os quais foram separados aleatoriamente em dois grupos: Placebo (Controle) e Tratado. O Grupo Tratado (n= 10) recebeu atendimento duas vezes por semana, por quatro semanas consecutivas (totalizando oito aplicações). Utilizou-se o laser de GaAs (904 nm), 6 J/cm^2, 0,38 mW/cm^2, área do feixe de 0,039 cm^2, com modo de emissão contínua. Realizou-se a aplicação do laser em quatro pontos pré-auriculares e um em meato acústico externo. O Grupo Placebo (n= 8) foi manipulado como o tratado, porém com o laser desligado. Para análise do nível de dor dos pacientes, empregou-se a Escala Visual Analógica (EVA) de dor, antes e após a terapia. Para a análise dos dados, empregou-se o teste *t* de *Student*, com nível de significância de 5% (p< 0,05). **Resultados:** Observou-se redução significativa (p< 0,05) do nível de dor do Grupo Tratado. **Conclusões:** A fotobiomodulação laser (GaAs, 904 nm) testada demonstrou ser positiva para o alívio da sintomatologia dolorosa em pacientes com DTM.

Palavras-chave: articulação temporomandibular; fotobiomodulação laser; dor.

Recebido: 5/02/2007 – **Revisado:** 29/06/2007 – **Aceito:** 8/11/2007

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Introduction

According to the American Academy of Orofacial Pain, temporomandibular dysfunction (TMD) is defined as a collective term that covers a large number of clinical problems that affect the masticatory muscles, the temporomandibular joint (TMJ) and associated structures, or both[1]. TMD is considered to be a subclassification of musculoskeletal disorders, and typically demonstrates a recurring or chronic course, with substantial fluctuations in its signs and symptoms over time. Common TMD signals and symptoms include noises in the TMJ, limited capacity to open the joint, deviations in the mandible and masticatory muscles movement patterns and/or orofacial pain[2].

Dysfunctions in the masticatory muscles are the main originating cause of non-dental pain in the orofacial region. The pain described as facial pain, headache or earache is commonly exacerbated by mandible function, and it is generally the patients' main complaint[3-5] and the most common reason for seeking treatment. TMDs are frequently accompanied by recurring headaches and pain in the neck area, showing a high incidence and large quantities of associated signs and symptoms, such as muscle spasms, reflex pain, difficulty in joint movement, crepitation, headache and hearing disorders[6]. The physical therapy approach and appropriate treatment plans for TMD must necessarily be based on the diagnosis[7].

Laser photobiomodulation is a low-cost noninvasive type of treatment that has been widely used for controlling a diversity of conditions, among them muscle-joint conditions. It is frequently used in clinical physical therapy practice for pain relief and tissue regeneration, and has been certified as beneficial in treating temporomandibular dysfunctions. Among the therapeutic effects are anti-inflammatory, analgesic and cell activity modulating actions, which have been proven in various studies[5,8-11].

Laser photobiomodulation activates the components of the mitochondrial respiratory chain, resulting in the start of a cascade of cellular events[12]. Once absorbed by the tissues, the laser radiation causes the release of substances like histamine, serotonin, bradykinin and prostaglandins that are related to pain. It is also capable of modifying cell and enzymatic activities, to inhibit or stimulate them[13].

The main bioelectric effect of the laser photobiomodulation is to maintain the cell membrane potential, which stops painful stimulation from reaching the nervous centers. This is due to the efficiency of the sodium-potassium pump, which is due to the higher availability of ATP resulting from the biochemical effects[14].

The analgesic effects of this therapeutic method are due to its action at different levels. Locally there is a reduction of inflammation through reabsorption of exudates and the elimination of pain-generating substances. There is also interference in the electrical message while transmitting the stimulus, thereby maintaining the ion gradient on both sides of the cell membrane and avoiding or reducing its depolarization. Furthermore, the laser acts on the thick nervous fibers and this stimulation causes blockages of the thin fibers[15]. Considering the importance of and the need for controlled clinical studies on the effects of laser therapy on TMD, this study had the aim of evaluating the states of pain in patients with TMD after laser photobiomodulation.

Materials and methods

This study was conducted in the Physical Therapy Clinic of the Universidade Estadual do Oeste do Paraná (Unioeste), Cascavel Campus. It was approved by the Research Ethics Committee of Unioeste, procedure no. 036/2006 – CEP. A double-blind, randomized and controlled study was carried out, in which the applicators used material previously prepared by the investigator.

For the study, 20 female patients aged 18 to 45 years were selected, who had been referred by dentists at the Dentistry Clinic of Unioeste, Occlusion Sector. These patients had been diagnosed with TMD, through a specific physical examination and a screening questionnaire for orofacial pain and TMD recommended by the American Academy of Orofacial Pain[1]. The patients were randomly divided in two equal groups according to the order of attendance at the service: control group (placebo, n= 10) and treated group (n= 10). However, two patients from the control group abandoned the study, and their data were disregarded for this study.

During the selection procedure, the patients underwent clinical assessment using a dental and physical therapy evaluation form developed for the study and follow-up, based on Okeson[1]. This form included identification of the patient, anamnesis, history of the disease, inspection, palpation of the musculature involved and functional examination of the TMJ.

To evaluate the pain, a visual analog scale (VAS) for pain was used, which was firstly explained to the patients and then applied in the initial evaluation and immediately after the laser application in all sessions. For the treatment, low-power gallium arsenide (GaAs) laser equipment was used. It had previously been calibrated, with a wavelength of 904 nm (Laserplus®), energy density of 6 J/cm^2, mean power density of 0.38 mW/cm^2, beam area of 0.039 cm^2 , mean power of 15 mW, and it was used in continuous emission mode for 16 seconds per point.

For the control group the same protocol mentioned above was followed, except that the laser equipment remained switched off during the applications. At the end of the study, all the patients in this group received the proposed assistance.

The laser application was performed bilaterally point-by-point, in contact with the surface, perpendicular to the skin[16,17], (Figure 1): with four points in the shape of a cross in the pre-auricular region; and one point in the external auditory meatus.

The medical care was provided twice a week, for four weeks, totaling eight sessions for each patient. No adverse effects were observed or reported by the patients participating in the study. The patients were extensively informed about the nature of the study and they signed an informed consent statement in order to participate in the study. For the statistical analysis of the pain levels, the Student *t* test and the Kruskal-Wallis test were used, with a significance level set at 5% ($p< 0.05$).

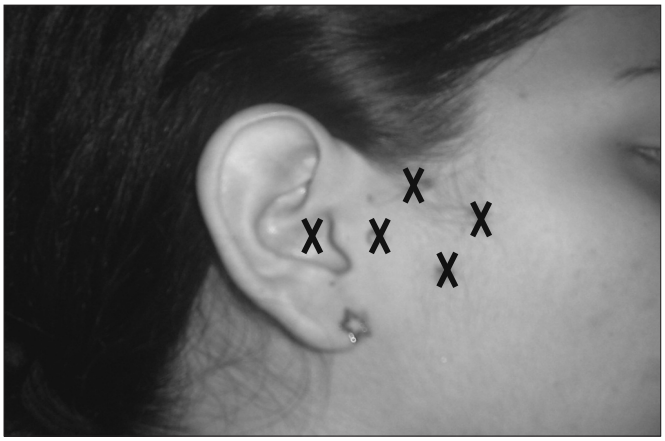

Figure 1. Laser therapy application points in pre-auricular region and external auditory meatus (X).

Results

It was observed that the patients' main complaint was pain, which could be a single complaint (61%) or was associated with other complaints (39%) such as joint cracking (16%), muscular tension (11%), tooth wear/fracturing (6%) and joint rigidity (6%). The location of the patients' pain varied and, in most cases (88%), it was in more than one location at the same time. The places that were most mentioned by the patients studied were the auricular (83%), temporal (72%), masseter muscle (66%) and neck regions (50%).

Correlations between the symptom duration in months and the factors related to worsening of the symptomatology showed that emotional tension was mentioned by all the patients as a modifying factor, regardless the duration of the symptomatology, and was accompanied by the functional activity performed (especially mastication of hard foods and physical work activities) or by temperature modifications, in which cold appeared to be the main modifying factor.

Regarding the frequency of painful symptomatology, a large proportion of the population studied reported complaints of pain on a daily (56%) or weekly (39%) basis. The time until the onset of symptoms ranged from seven up to more than 60 months in the selected sample.

In Figure 2, it can be seen that the painful symptomatology of the treated group, initially with a mean of 4.6 points, which ranged from light and occasional to strong and constant pain. A significant statistical reduction was found ($p< 0.05$) from the fifth session onwards, and this was maintained until the end of the treatment, when the mean

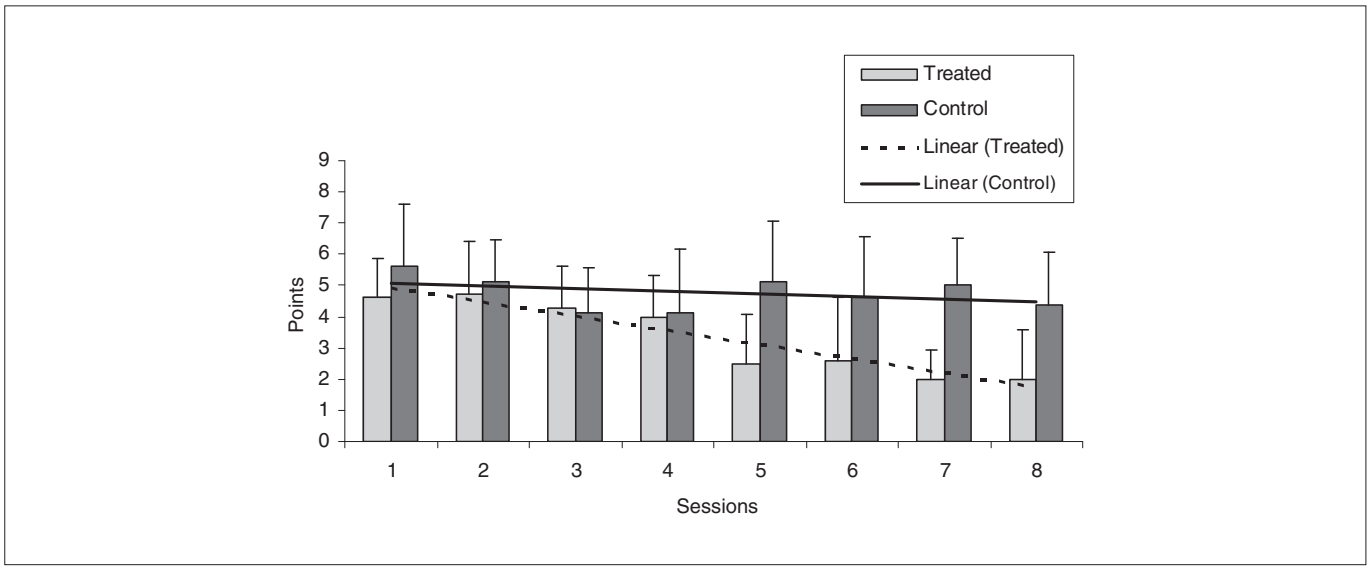

Figure 2. Mean VAS scores between the sessions.

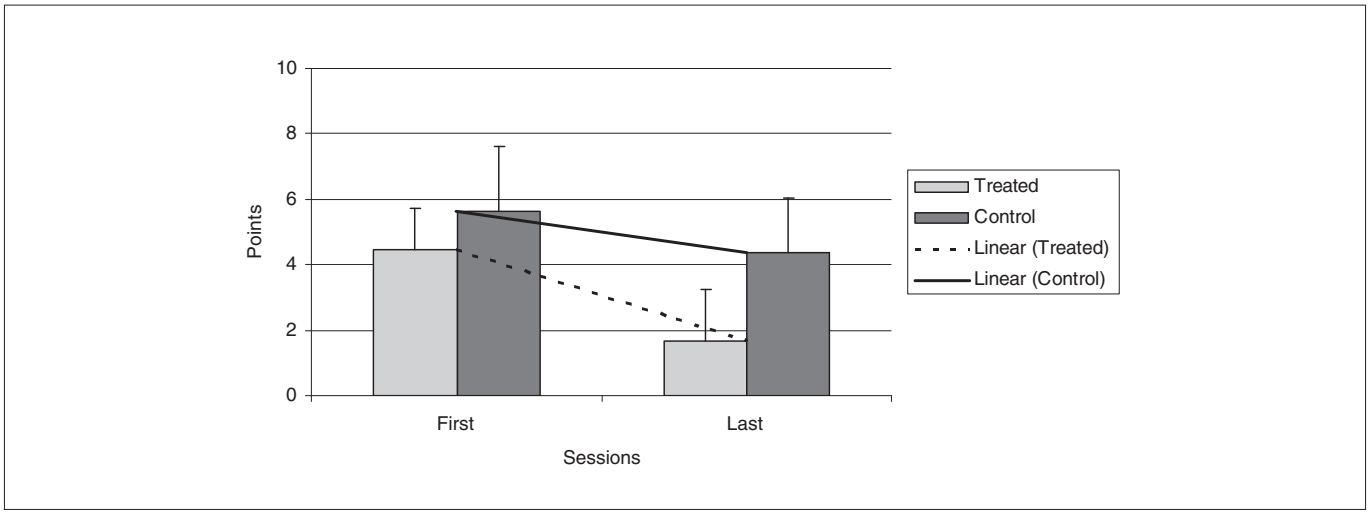

Figure 3. Comparison of the mean VAS scores between the first and last sessions.

score from the VAS was 2, and the painful symptomatology ranged from strong and occasional to absence of painful symptomatology.

The control group initially had a mean of 5.6 points, with painful symptomatology varying from unbearable and occasional to light and occasional. They demonstrated a slight reduction of the painful conditions in the first sessions, without statistical significance ($p > 0.05$). Oscillations in the pain levels were recorded throughout the treatment, reaching the last session with a mean VAS score of 4.4, with painful symptomatology ranging from strong and constant to very light and constant.

Figure 3 shows the comparisons between the control group and the treatment group, for the mean VAS scores that were obtained, between the first and last sessions. It can be seen that by the end of the treatment, both groups reported reductions in the painful symptomatology, but only the experimental group presented statistically significant results ($p < 0.05$).

Discussion

Low-power laser radiation is a widely used research source in many fields of health studies, since the effects of this therapy are dose dependent[18], yet the action of this radiation on different biological tissues and in different pathological conditions is still unclear. Through this study, it was sought to clarify the usage of laser photobiomodulation for treating pain in patients with TMD, which is an extremely common pathological condition seen in physical therapy consultation offices.

Studies have shown that pain shows an accentuated incidence in TMD, in addition to a large quantity of associated signs and symptoms, such as headaches and neck pain[3-5]. In the present study, it was observed that the main complaint of the patients under investigation was pain, which was manifested alone or in associated with other complaints such as joint cracking, muscle tension, tooth wear/fracturing and joint rigidity. Its location in the patients varied and it was generally found in more than one location at the same time. The most frequent locations in this study were the auricular, temporal, masseter muscle and cervical regions.

Through the VAS, the evolution of the painful symptomatology could be observed in both groups. It was seen that in the treated group, there was a statistically significant reduction ($p < 0.05$) from the fifth session onwards, which was then maintained until the end of the treatment. In the control group there was also an improvement of the pain level, although without statistical significance ($p > 0.05$), demonstrating oscillations in pain levels over the course of the treatment.

The radiation was emitted in the near infrared region (904 nm), indicating a low absorption coefficient and, consequently, maximum tissue penetration, which promoted its interaction with molecular and cell structures[8,12]. Once absorbed by the tissues, laser radiation causes release of substances like histamine, serotonin, bradykinin and prostaglandins that are related to pain. It is also able to modify cell and enzymatic activities, through inhibiting or stimulating them[13]. For this to occur, the energy density is the most important parameter in the technique. If the dose applied is too low, the expected result is not obtained, and if it is too high, an inhibitory effect might be obtained, instead of a stimulative effect[18].

Since TMD is a chronic disease, 6 J/cm^2 were used. Laser irradiation exerts a stimulus on the cell mitochondria, causing increased ATP production inside the cells and consequent acceleration of mitosis. This leads to increased oxygen consumption and cell respiration activation, thus eliminating

the anaerobic activities that occur in an inflammatory process[12,19,20]. Other mechanisms that have been reported for the beneficial effects induced by laser radiation include modulation of prostaglandin levels, increased fibroblastic activity, alterations to the somatosensory evoked potential and velocity of nervous conduction, as well as, improvements in the local circulation of the treated tissues, thereby causing pain relief and tissue repair[9,21].

In the present study, 18 female patients of mean age of 27 ± 7 years with a diagnosis of TMD were analyzed. Studies have shown the predominance of dysfunction in this group of patients, i.e., women of the reproductive age[22-24]. There is generalized flaccidity in female tissues that may be due to increased estrogen levels[1]. Women's joints are usually more flexible and looser than men's. TMDs present their highest prevalence among women of the reproductive age. The pattern of onset of the disease following puberty and reduction of prevalence rates in the postmenopausal period suggests that reproductive hormones may have an important role in its etiology[25].

A study carried out through a literature review on articles published between 1975 and 2002 states that the prevalence of TMD is from two to five times greater among women than among men in the study samples, because of female reproductive hormones[23]. Another important reason for the predominance of TMDs among women is that women show higher stress levels than do men, thus reporting a higher incidence of diseases with psychosomatic involvement[26]. High stress levels not only may increase muscle tonicity in the head and neck, but also may raise the levels of parafunctional muscle activity[1].

The results obtained from the present study showed the complexity of TMD, both in relation to the patients' symptomatology (since it is subject to the influences of different factors, among which are emotional factors and activities preformed) and in relation to its treatment. Individuals' muscle activity behavior is difficult to standardize, thus making it difficult to develop protocols for efficient treatments.

The clinical evaluation of pain was carried out through a double-blind study, because of the investigator's possible influence on the opinions of the patients undergoing the treatment. Although the present study was not carried out with a long-term follow-up, the pain reduction in the treatment group, which started after the third session and became accentuated after the fifth session, suggested a gradual improvement in symptomatology. The differences found in the VAS reflected an immediate response to the laser applications, independent of the kind of treatment (real or placebo).

In a placebo-controlled clinical trial on the effectiveness of laser photobiomodulation, Kulekcioglu et al.[8] observed a significant pain reduction both in the treated and in the placebo group. The placebo effect was discussed in a study by Gam, Thorsen and Lonnberg, which through meta-analysis observed the effects of laser photobiomodulation on musculoskeletal pain, finding minimal differences between the treated and the placebo groups[27]. According to these authors, a good relationship between the professional and the patient, associated with the "high-tech" appearance of the laser, may explain the improvements in the patients' symptomatology. Moreover, it can be suggested that the limiting and chronic aspects of TMD symptoms, with periods of symptom reduction, might partly explain the pain reduction in the placebo group[28].

A systematic review by McNeely et al.[3], published in 2006, examined the efficiency of different physical therapy interventions including laser photobiomodulation, for treating TMD. Based on their findings, no differences between the studied groups were observed regarding pain relief. No evidence was found regarding the effects of electrotherapy, including the laser, for pain reduction. However, there were significant improvements in the active and passive mouth opening and in the amplitude of lateral deviations following the laser treatment. Based on preliminary findings, these authors concluded that, although the technique may be potentially effective for TMD, more rigorously controlled clinical trials are needed in order to confirm this conclusion.

Kato et al.[5] carried out a comparative study between transcutaneous electrical nerve stimulation (TENS) and laser photobiomodulation in patients with TMD and observed, through VAS, that there was a reduction in the pain levels and improvements in the maximum mouth opening in both treated groups. Muscle palpation showed significant differences for the laser group.

Gur et al.[9] carried out a prospective, double-blind, randomized and controlled study among patients with myofascial pain syndrome in the neck, with the use of GaAs (904 nm). They observed a reduction in pain levels and improvements in functional capacity and quality of life among their patients. Considering the differences that were found in the VAS in the present study between the treatment and control groups, it can be suggested that the cumulative effects of the laser were responsible for pain reduction[5,9,10,27,29,30].

Based on the present study, it can be concluded that laser photobiomodulation promoted satisfactory results regarding controlling the pain levels of patients with TMD. Thus, it can be suggested as an efficient, non-invasive, low-cost treatment method for these patients with the dose level tested. However, it is suggested that further research should be carried out to prove and clarify this therapeutic protocol.

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