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Infrared Laser Therapy Effectiveness Evaluation in Temporomandibular Disorders Using Electromyography - A Preliminary Study

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Abstract

Introduction: Temporomandibular disorders (TMD) are a collective term embracing a number of clinical problems involving masticatory musculature, temporomandibular joint (TMJ) and associated structures, or both. These disorders can be serious illnesses that can reduce the individual's quality of life.

Aim of the Study: The aim of this study was to evaluate the effectiveness of photobiomodulation in temporomandibular disorders (TMD) treatment.

Materials and Methods: Twelve patients selected for the experiments were randomly distributed in two groups. The Craniomandibular Index, proposed by Friction, was used in order to provide standardization in patient's selection. Patients in the first group were submitted to laser irradiation procedure using an AlGaAs laser - emission at 808 nm, 100 mW of output power, in punctual and contact mode, spot of 0.0028 cm^2 and energy of 2.8 J/point. Patients in the second group, control group, were submitted to an interocclusal device (orthotic plate) and photobiomodulation was performed only for simulation with the equipment turned off. The evaluation of laser radiation effectiveness on the muscular tissue was made through electromyography surface and electrodes. The electromyography was obtained before and after laser irradiation (15 and 30 minutes after irradiation).

Results: The statistical analysis showed laser therapy effectiveness. The procedure reduced the muscular electric activity, providing muscular relaxation; as also was responsible for a reduction of pain and of the inflammatory condition.

Conclusion: It was verified the effectiveness of the laser as an auxiliary treatment for TMD.

Keywords: *Laser Therapy; Temporomandibular Joint; Temporomandibular Disorder; Electromyograph (EMG)*

Introduction

Since the laser was developed in 1960, many researchers have been doing laser-related work and developing a number of devices. In the medical field, several types of lasers (with different wavelengths and power levels) have been used for medical treatment [1]. Some studies in the orthopedic area indicate that photobiomodulation (PBM) is effective in modulating inflammatory processes and pain man-

agement in patients with rheumatoid arthritis and have positive effects in animal studies with degenerative articular diseases [2-4]. In orofacial pain, PBM use demonstrates a broad range of benefits in the treatment of maxillofacial disorders [5-7].

Temporomandibular disorders (TMD) are a collective term embracing a number of clinical problems involving masticatory musculature, temporomandibular joint (TMJ) and associated structures, or both. TMD has been identified as a major cause of non-dental pain in the orofacial region and considered a sub-classification of musculoskeletal disorders [8,9].

Temporomandibular disorders treatment is conducted in accordance with the structures involved. A range of interventions can be established for different tissues and causes, and treatment can be carried using analgesics, anti-inflammatory, and myorelaxant drugs, as also cryotherapy, thermotherapy, transcutaneous electrical neural stimulation (TENS), ultrasound, acupuncture, massage, stretching, PBM, interocclusal plate, botulinum toxin and a variety of other treatments [10].

When considering PBM for TMD treatment, appropriate parameters of the laser may act as analgesic and anti-inflammatory mediators to promote muscular relaxation. According to some studies, PBM is an important tool that has brought numerous benefits in TMD treatments [7].

Aim of the Study

The aim of this study was to evaluate the immediate effect of the effectiveness of PBM (808 nm) as an additional aid in treatment of patients with temporomandibular disorders using electromyography as a method of analysis.

Materials and Methods

Ethical procedures

The protocol used in this study was approved by the Ethics Committee on Research with Human Beings of the Faculty of Dentistry at the University of Pernambuco (CAAE:009.0.097.000-07).

Sample description

Twelve patients were selected, including nine female and three male patients, who had signs and or symptoms of TMD, with ages ranging from 20 to 46 years, with different types of occlusion: partial edentulous patients (less than six teeth by arch) and total edentulous patients. Patients were selected at the Faculty of Dentistry in the University of Pernambuco. Craniomandibular Index proposed by Fricton was used as inclusion criteria to this selection [11]. Patients were selected randomly and distributed into two groups:

- Group I: Patients were submitted to irradiation with laser, aluminum gallium arsenide (AlGaAs), emitting infrared radiation, wavelength of 808 nm, power of 100 mW, delivery system for direct skin contact, focus area (laser spot) of 0.0028 cm^2, energy by point 2.8J and total time per point of 28s. This equipment was manufactured by DMC® Equipments Company (São Carlos, SP, Brazil).
- Group II (control): This group used an interocclusal device (stabilizing plate). This kind of device allows the removal of horizontal and vertical torques providing greater occlusal stability and muscular relaxation to patients. The plate was installed 48 hours before the sham laser application. The group II sham laser application was carried with a mock device (DMC® Equipments Company (São Carlos, SP, Brazil) identical to the one used in group I, including the beep system. The application protocol was identical to the group I, 28 seconds per point.

Electromyography (EMG) was the method employed for electronic registration of muscular function, measuring the electrical activity, both for normal activity, and for analysis of temporomandibular disorders. EMG is responsible for a new dimension to dental treatment, both for symptomatic and asymptomatic patients, providing the ability to ensure physiological results.

EMG was performed using surface electromyography (BioPak System, Bioresearch Assoc. Inc. Milwaukee, WI, USA) and electrodes were manufactured at the same location.

Surface electrodes bilaterally placed on superficial masseter muscle and anterior temporal muscle allowed to observe changes in electrical activity of examined muscles in rest mandibular position, before laser application as also after 15 and 30 minutes.

The normal electrical activity in rest position of the superficial masseter muscle and anterior temporal muscle usually ranges from 0.5 to 2.0 microvolts.

Figure 1 shows surface electrodes positioned and figure 2 shows demarcation points for the subsequent repositioning of them.

Figure 1: *Electrodes surface placed in position.*

Figure 2: *Demarcation for the subsequent repositioning of electrodes in the posterior measures.*

Electrodes placement

The area of electrodes placement was totally clean and defatted with neutral soap and water, alcohol (70%) was used immediately before electrodes placement.

Experimental procedures

Patients were evaluated according to the anamnesis, clinical examination and electromyographic tests (confirmation of the muscular electrical activity - EMG).

For group I and II, the following points were irradiated: three points in each muscle (superficial masseter muscle and anterior temporal muscle) in accordance with the position of longitudinal muscle fibers. Besides, other points were irradiated: Temporomandibular Joint (TMJ), anterior pole of condyle (maximum intercuspation position - MIP), posterior pole of condyle (open mouth), superior corner of the condyle (open mouth), disc space of the TMJ (maximum intercuspation position), bilaminar zone (open mouth), intra-auricular points (aiming laser's interception in the auriculo-temporal nerve) and condyle´s neck (site of insertion of fasciculus of lateral pterygoid muscle, all these points were irradiated bilaterally). These points were chosen for laser irradiation due to its close relationship with the overload articular, condylar position during the function, relationship condyle/disc, increased muscular activity and intracapsular compressions.

Analytical procedures

Data analysis was performed through statistical analysis: mean values and standard deviation (Techniques of Descriptive Statistics). Other usual tests were utilized: Mann-Whitney test, Wilcoxon test for paired samples and F test (ANOVA) for repeated measures with comparisons of Bonferroni, including adjusts for degrees of freedom of Greenhouse-Geiser (Techniques of Statistical Inference).

It is necessary to emphasize that the choice of Mann-Whitney test and Wilcoxon test for paired data was due to sample size.

Data was shipped on EXCEL spreadsheet and data analysis was performed by SPSS (Statistical Package for the Social Sciences), version 13. The statistical tests were performed using a 5.0% level of significance.

Results

Table 1 shows mean values and standard deviation of muscular electrical activity measured for each muscle, moment of assessment and sample group. According to table 1, in the laser group (Group I), mean values decreased after evaluation period more significantly before irradiation with laser and decreased after 30 minutes in each muscle. In the control group, except for left superficial masseter muscle in which mean values decreased after irradiation period, in relation to other muscles, there was a reduction in the values obtained before the irradiation compared to that obtained after 15 minutes and an increase in values in the assessment after 30 minutes. In the assessment before laser irradiation, mean values were correspondingly higher in the laser group than in the control group, whereas in the assessment after 30 minutes, except for right anterior temporal muscle, the mean values were lower in the laser group compared to the control group (Group II). Through statistical analysis it was observed a significant difference between the two groups in the assessment after 15 minutes on the right anterior temporal muscle and left anterior temporal muscle and also there was a significant difference in the evaluation of 30 minutes after laser application on the right superficial masseter muscle. In the laser group there was a significant difference between different moments of evaluation and through paired tests the comparisons provided a significant difference between the initial assessment and after 30 minutes for the right anterior temporal muscle, left anterior temporal muscle and superficial masseter muscle, between the instant before laser application compared to other two assessments in the right superficial masseter muscle.

Table 2 shows the mean values and standard deviation of the absolute variation (reduction) between the evaluation before laser application and after 15 minutes, from 15 to 30 minutes and from before the irradiation to 30 minutes later, for each muscle and per group. This table shows that in the laser group the average of the differences were all positive, which indicates, on average, a reduction in muscular electrical activity; the mean values of the differences from before the irradiation to 15 minutes later were higher than the averages of differences from 15 to 30 minutes later. In the control group, the mean values of differences from before the irradiation to 15 minutes

		Group		
Muscle	**Evaluation period**	**Laser**	**Control**	**(p) Value**
		Mean value (PD)	**Mean value (PD)**	
Right anterior temporal muscle	Rest period before irradiation	3.46 (1.58) (A)	1.58 (0.66)	$p^{(1)} = 0.073$
	15 minutes after irradiation	2.29 (1.02) (AB)	1.05 (0.06)	$p^{(1)} = 0.004$*
	30 minutes after irradiation	1.59 (0.47) (B)	1.35 (0.39)	$p^{(1)} = 0.368$
	(P) Value	$p^{(2)} = 0.009$*	$p^{(2)} = 0.345$	
Left anterior temporal muscle	Rest period before irradiation	4.03 (2.20) (A)	2.53 (0.88)	$p^{(1)} = 0.109$
	15 minutes after irradiation	2.80 (1.83) (AB)	1.25 (0.24)	$p^{(1)} = 0.008$*
	30 minutes after irradiation	1.98 (1,33) (B)	2.35 (1.14)	$p^{(1)} = 0.461$
	(P) Value	$p^{(2)} = 0.008$*	$p^{(2)} = 0.127$	
Right superficial masseter	Rest period before irradiation	3.26 (1.53) (A)	2.78 (1.28)	$p^{(1)} = 0.570$
	15 minutes after irradiation	1.63 (0.77) (B)	2.60 (0.76)	$p^{(1)} = 0.109$
	30 minutes after irradiation	1.18 (0.38) (B)	3.03 (1.23)	$p^{(1)} = 0.008$*
	(p) Value	$p^{(2)} = 0.003$*	$p^{(2)} = 0.666$	
Left superficial masseter	Rest period before irradiation	3.50 (1.55) (A)	2.73 (2.14)	$p^{(1)} = 0.570$
	15 minutes after irradiation	2.11 (1.21) (AB)	2.43 (1.49)	$p^{(1)} = 0.808$
	30 minutes after irradiation	1.39 (0.38) (B)	1.88 (1.11)	$p^{(1)} = 0.461$
	(p) Value	$P^{(2)} = 0.004$*	$p^{(2)} = 0.612$	

Table 1: *Average and standard deviation of the electric activity considering evaluation period and muscle, for sample group.*

(*): Significant difference - 5.0% level of significance.

(1): Through Mann-Whitney, test for group comparisons.

(2): Through test F (ANOVA) for repeated measures, with Greenhouse-Geisser correction, for comparison between evaluated periods.

PS: If all letters in parenthesis are distinct there is a significant difference in the corresponding evaluations, through Bonferroni test.

later were all positive, while the mean of the differences from 15 to 30 minutes, with the exception of the right superficial masseter muscle, were all negative. The average of changes was correspondingly higher in the laser group than in the control group, however, a significant difference between the two groups at 5.0% of significance level were recorded between the time of 15 to 30 minutes for right anterior temporal muscle, left anterior temporal muscle and before laser irradiation after 30 minutes on right superficial masseter muscle. Comparing the differences between the initial period of 15 minutes and 15 to 30 minutes the only significant difference was recorded for the right superficial masseter muscle in the laser group.

The results of table 3 and 4 were obtained being considered the mean values of four muscles in each moment of evaluation.

Table 3 presents the mean values before irradiation and 15 minutes later, correspondingly higher in the group laser than in the group control, while mean value in the evaluation after 30 minutes were higher in the group control than in the laser group. In the laser group: a reduction of the mean value was observed along the evaluation period; the highest value was observed before laser application and the smallest value was observed after 30 minutes of laser application. In the group control: a reduction of the mean value was observed before laser application till 15 minutes; an increase was observed in the evaluation from 15 to 30 minutes later. In the group control it was not observed a significant difference between groups for the provided evaluations and in the laser group significant differences were observed.

		Group		
Muscle	**Differences (1)**	**Laser**	**Control**	**(p) Value**
		Mean value (PD)	**Mean Value (PD)**	
Right anterior temporal	Between time one and two	1.18 (1.36)	0.53 (0.68)	$p^{(2)} = 0.570$
	Between time two and three	0.70 (0,86)	-0.30 (0,36)	$p^{(2)} = 0.008$*
	Between time one and three	1.88 (1,55)	0.23 (0,85)	$p^{(2)} = 0.109$
	(p) Value	$p^{(3)} = 0.484$	$p^{(3)} = 0.068$	
Left anterior temporal	Between time one and two	1.23 (1.36)	1.28 (0.88)	$p^{(2)} = 0.808$
	Between time two and three	0.83 (1.12)	-1.10 (1.17)	$p^{(2)} = 0.028$*
	Between time one and three	2.05 (1.72)	0.18 (1.21)	$p^{(2)} = 0.109$
	(p) Value	$p^{(3)} = 0.674$	$p^{(3)} = 0.068$	
Right superficial masseter	Between time one and two	1.64 (1.21)	0.18 (1.34)	$p^{(2)} = 0.109$
	Between time two and three	0.45 (0.58)	-0.43 (0.78)	$p^{(2)} = 0.109$
	Between time one and three	2.09 (1.42)	-0.25 (0.95)	$p^{(2)} = 0.004$*
	(p) Value	$p^{(3)} = 0.012$*	$p^{(3)} = 1.000$	
Left superficial masseter	Between time one and two	1.39 (1.53)	0.30 (2.14)	$p^{(2)} = 0.368$
	Between time two and three	0.73 (1.00)	0.55 (0.89)	$p^{(2)} = 0.683$
	Between time one and three	2.11 (1.50)	0.85 (2.67)	$p^{(2)} = 0.283$
	(p) Value	$p^{(3)} = 0.401$	$p^{(3)} = 0.715$	

Table 2: *Absolute difference of the electric activity considering the evaluated periods for each muscle, for sample group.*

(*): Significant difference - 5.0% level of significance.

(1): Time of evaluation: Time 1 = rest time before laser application; Time 2 = 15 minutes after laser application; Time 3 = 30 minutes after laser application.

(2): Through Mann-Whitney, test for group comparisons.

(3): Through Wilcoxon test for paired data, in order to provide a comparison of the time before laser to 15 minutes and from 15 minutes to 30 minutes.

	Group		
Evaluation period	**Laser**	**Control**	**(p) Value**
	Mean value (PD)	**Mean value (PD)**	
Rest period before irradiation	3.56 (0.79)	2.40 (1.08)	$p^{(1)} = 0.109$
15 minutes after irradiation	2.21 (0.78)	1.83 (0.56)	$p^{(1)} = 0.368$
30 minutes after irradiation	1.53 (0.47)	2.15 (0.91)	$p^{(1)} = 0.154$
(p) Value	$p^{(2)} < 0.001$*	$p^{(2)} = 0.466$	

Table 3: *Measures of the averages of the muscular electric activity in agreement with the period of evaluation, for sample group.*

(*): Significant difference - 5.0% level of significance.

(1): Time of evaluation: 1 = rest time before laser application; Time 2 = 15 minutes after laser application; Time 3 = 30 minutes after laser application.

(2): Through Mann-Whitney, test for group comparisons.

(3): Through Wilcoxon test for paired data, in order to provide a comparison of the time before laser to 15 minutes and from 15 minutes to 30 minutes.

Table 4 presents the mean values and the standard deviation of the absolute differences between the initial evaluation and each one of the evaluations according to the sample group. In this table it is possible to observe that the medium values indicate that there was reduction of the muscular activity in each one of the groups in relation to the initial value measured (before irradiation); the mean of the variations were correspondingly higher in the group of the laser than in the group control. The average of the variation increased along the time in the laser group and in the group control the average was reduced considering the evaluation after 15 minutes compared to the one after 30 minutes (from 0.57 to 0.25). In the group of laser irradiation the average of the difference before laser irradiation to 15 minutes later was higher than the average of the difference from 15 to 30 minutes after laser irradiation, while in the group control there was reduction in the first interval and increment for the interval of time from 15 minutes to 30 minutes after laser irradiation. Significant differences at 5.0% significance level between the groups were verified for the variations from 15 to 30 minutes, as also in total variation and between the two variations of the laser group ($p < 0.05$).

	Group		
Evaluation period [1]	**Laser**	**Control**	**(p) Value**
	Mean value (PD)	**Mean value (PD)**	
Between time one and two	1.36 (0.41)	0.57 (1.00)	$P^{(2)} = 0.154$
Between time two and three	0.68 (0.36)	-0.32 (0.38)	$P^{(2)} = 0.004$*
Between time one and three	2.03 (0.48)	0.25 (1.25)	$P^{(2)} = 0.008$*
(p) Value	$p^{(3)} = 0.025$*	$p^{(3)} = 0.066$	

Table 4: *Absolute difference of muscular electric activity averages according to the period of evaluation, for the sample group.*

(*): Significant difference - 5.0% level of significance.

(1): Time of evaluation: Time 1 = rest time before laser application; Time 2 = 15 minutes after laser application; Time 3 = 30 minutes after laser application.

(2): Through Mann-Whitney, test for group comparisons.

(3): Through Wilcoxon test for paired data, in order to provide a comparison of the time before laser to 15 minutes and from 15 minutes to 30 minutes.

Table 5 presents the statistical analysis for the percentual relative differences between the initial evaluation and each one of the evaluations according to the studied group. In table 5 it is possible to verify that: the medium values indicate that there was reduction of the muscular activity in each one of the groups compared to the initial measured value; the averages of the variations were correspondingly higher in the group of the laser than in the group control. The average of the variation increased along the time in the laser group while in the group control the obtained average was reduced from 15 to 30 minutes of evaluation (from 17.59% to 2.91%). In the laser group the average of the difference before irradiation to 15 minutes was higher than the average of the difference from 15 to 30 minutes while in the control group there was a reduction in the first interval and increment of time from 15 minutes to 30 minutes. Significant differences at 5.0% significance level between groups were verified in the values from 15 to 30 minutes and in the total variation as also between the two variations of the laser group ($p < 0.05$).

In this study it was observed that the average of the electrical activity of muscle measured 15 minutes after irradiation decreased in the two groups; from this moment to 30 minutes after irradiation it was only observed a decrease in laser group measured values.

In laser group evaluation a significant difference was observed while in control group it was not observed a significant difference.

A significant difference was verified between group comparisons in relation to the variations of the measures from 15 to 30 minutes and from the initial evaluation to 30 minutes of laser irradiation.

	Group		
Evaluation period (1)	**Laser**	**Control**	**(p) Value**
	Mean value (PD)	**Mean value (PD)**	
Between time one and two	38.83 (10,77)	17.59 (28,12)	$p^{(2)} = 0.283$
Between time two and three	29.50(57,62)	-14.65 (16,40)	$p^{(2)} = 0.004$*
Between time one and three	57.08 (7,52)	2.91 (44,91)	$p^{(2)} = 0.004$*
(p) Value	$p^{(3)} = 0.123$	$p^{(3)} = 0.068$	

Table 5: *Percentile difference of the averages of muscles according to the period of evaluation, for sample group.*

(*): Significant difference - 5.0% level of significance.

(1): Time of evaluation: Time 1 = rest time before laser application; Time 2 = 15 minutes after laser application; Time 3 = 30 minutes after laser application.

(2): Through Mann-Whitney, test for group comparisons.

(3): Through Wilcoxon test for paired data, in order to provide a comparison of the time before laser to 15 minutes and from 15 minutes to 30 minutes.

Discussion

In the present study, the range of electronic registration of muscular function by EMG was evaluated in patients with TMD after laser therapy. The main finding of this study was that PBM can promote muscle relaxation in the masseter and temporalis muscles.

There are a variety of methods to evaluate TMD, but all of them have limitations. For example, the evaluation of pain is a subject not totally controlled in the clinical and pain research areas, due to a complex procedure that involves some concepts and methods, and requires the assessment of biological structural and functional, as well as the emotional, cognitive and behavioral aspects of the painful experience [8,10]. The procedure for EMG signals has been described in the literature previously showing an objective method of evaluation to measure the muscular electric activity of oral muscles [12,13].

The treatment of TMD must be based on a correct diagnosis established from information on possible etiologic factors, signs and symptoms of each patient, and the clinical treatment protocol varies according to the level of damage of muscle and TMJ structures, clinical symptoms and duration of the problem. Thus, the treatment must initiate with therapy to relieve the symptoms, diminish pain, restore function and allow the patient to come back to daily activities. The treatment can include pharmacologic therapy, interocclusal plate, thermotherapy, transcutaneous electrical neural stimulation (TENS), ultrasound, acupuncture, massage, stretching and sometimes association of two or more therapies [10].

More specifically, laser therapy has been used extensively to treat musculoskeletal disorders and TMJ [6]. Although PBM has been studied since the early 1960s, its parameters to treat TMD are not clear, showing a lack of standardization in dosimetry parameters [7]. This absence of standardization and limited evidence in literature, ends limiting the technique usage to the majority of clinical practitioners.

Tissue penetration is usually determined by the wavelength utilized, due absorption and scattering characteristics. The infrared wavelength used in this present study is considered the most appropriate to treat TMD, once it has the higher levels of tissue penetration (around 810 nm). The treatment of TMD with wavelengths is described in literature, despites their limitations of tissue penetration [14].

In the present study, the results through EMG demonstrated that the Group I presented a higher muscle relaxation compared to group II. Therefore, in this study, it was observed a positive result in the group treated with laser. Additionally, it is relevant to point out that in

this study, marks on participants' skin were made to ensure the same electrode placement position across the different measurements, and also the same equipment was used during the experiment. The measurements of all patients occurred on the same day, to avoid EMG discrepancies.

Photobiomodulation seems to be in accordance with TMD's treatment, being a non-invasive, safe, effective alternative without reported side effects. The results obtained in this study indicate that laser therapy could be an adjuvant in the management of patients with TMD. Randomized, placebo-controlled clinical trials with a significant sample must be performed in order to validate this therapy.

Conclusion

- Photobiomodulation reduced muscular electric activity providing an immediate muscular relaxation.
- Photobiomodulation might be considered as an adjuvant therapy to treat TMD patients.
- It is possible to consider the use of electromyography as a tool for the study of TMD.

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