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Original Article

Electromyographic evaluation of a low-level laser protocol for the treatment of temporomandibular disorder: a randomized, controlled, blind trial

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Abstract. [Purpose] Problems involving the temporomandibular joint and associated structures can lead to temporomandibular disorder (TMD). The aim of the present study was to evaluate muscle activity in individuals with a diagnosis of TMD before and after treatment with low-level laser therapy (LLLT) through the use of electromyography (EMG). [Subjects and Methods] Male and female individuals aged 14 to 23 years were evaluated. TMD was determined by a clinical examination and the administration of the Research Diagnostic Criteria for Temporomandibular Disorders, followed by the evaluation of sensitivity to palpation of the masseter and anterior temporal muscles as well as the EMG determination of muscle activity. The participants were randomly allocated to an active LLLT group (n=9) and sham group (n=7). Twelve sessions of LLLT were conducted using a wavelength of 780 nm, energy density of 25 J/cm^2, power of 50 mW, power density of 1.25 W/cm^2 and a 20-second exposure time or sham LLLT. Muscle activity was determined prior to treatment and after the last session. [Results] During the isometric evaluation of the masseter and anterior temporal muscles, an increase in the mean EMG signal was found in the group submitted to active LLLT. When evaluated individually, some participants in the active LLLT group demonstrated a reduction in muscle activity, but no significant differences were found in the mean EMG signal between the initial and final evaluations. [Conclusion] Further studies with a larger sample size are needed to confirm the present findings.

Key words: Electromyography, Temporomandibular joint disorder, Low-level laser therapy

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INTRODUCTION

Temporomandibular disorder (TMD) is a set of clinical signs and symptoms that affect the masticatory muscles, temporomandibular joint (TMJ) and associated structures, such as muscle sensitivity, pain in one or both TMJs, limited mandibular movements, joint sounds and headache as well as possible neck pain, vertigo, earache and ringing in the ears. Different clinical conditions can cause TMD, which may also be associated with psychological factors[1–7)].

Due to the multifactor etiology of TMD, techniques have been proposed for the treatment of signs and symptoms of this disorder, such as bite plate usage, acupuncture, kinesiotherapy, exercises, manual therapy, massage therapy, postural training, psychotherapy, joint mobilization, medicinal therapy and laser therapy[8–11)]. Low-level laser therapy (LLLT) is a noninvasive, non-pharmacological form of treatment that, according to numerous studies, has demonstrated beneficial results regarding the treatment of pain stemming from TMD. Radiance in LLLT is situated between the visible and infrared portions

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of the electromagnetic wave spectrum, which have the characteristics of monochromaticity, coherence and unidirectionality[4, 5, 9, 12–20]. The therapeutic effects of LLLT are reported to be modulation of the inflammatory process and analgesia related to an increase in the production of β-endorphins, reductions in the secretion of histamine and acetylcholine, a reduction in the synthesis of bradykinin and an increase in the production of adenosine triphosphate, which can result in muscle relaxation and an increase in local blood micro-circulation, thereby accelerating the removal of catabolites from tissues[4, 5, 21, 22].

Electromyography (EMG) allows the evaluation of muscle function and dysfunction at rest as well as during occlusion and the chewing process, which helps in the diagnosis and knowledge of muscle physiology as well as the differential diagnosis and monitoring of TMD during prescribed therapies[23, 24]. The aim of the present study was to evaluate muscle activity in young individuals with a diagnosis of TMD before and after treatment with LLLT using EMG as the examination technique.

SUBJECTS AND METHODS

This study was conducted in accordance with the regulatory norms for research involving human subjects, was submitted to the Research Ethics Committee of the Universidade Nove de Julho (process number 40455) and is registered with ClinicalTrials.gov (nº NCT0184600). All the volunteers/guardians signed a statement of informed consent agreeing to participate in the study.

Male and female adolescents and young adults were recruited from the clinics of the undergraduate and graduate programs of Nove de Julho University (Vergueiro Campus, São Paulo, SP, Brazil). All individuals within the target age range were asked to participate in an initial evaluation for TMD. The convenience sample was based on the fact that the present investigation is a preliminary study.

Individuals aged 14 to 23 years with a diagnosis of TMD and a signed statement of informed consent were included. Individuals with dentofacial anomalies, incomplete permanent dentition through to the second molars, undergoing orthodontic or orthopedic treatment of the jaws, undergoing psychological treatment and/or physical therapy using muscle relaxants, anti-inflammatory agents or bite plates were excluded from the study.

Sealed, opaque envelopes were used for the random allocation of the volunteers to the different groups. Prior to the initial evaluation, each volunteer opened an envelope with a card stipulating to which group he/she would be allocated, but was not allowed to see the card in order to ensure the blinding of the participants. All individuals were submitted to an initial EMG evaluation and a second EMG evaluation after the last treatment session.

The Research Diagnostic Criteria for Temporomandibular Disorders (RDC-TMD) were used for the diagnosis of TMD in eligible volunteers prior to any intervention. A specific clinical examination was also performed by a single examiner who had undergone training exercises. The clinical examination consisted of palpation of the trapezius, sternocleidomastoid, temporal, masseter, digastric and medial pterygoid muscles as well as palpation of the TMJs. An analysis of mandibular movements was also performed by the same examiner with the aid of digital calipers to measure vertical and horizontal movements and a stethoscope for the determination of joint sounds. Frequent headaches, facial pain, fatigue and difficulty during chewing, bruxism, psychological aspects and parafunctional habits were also investigated.

The EMG signals were determined using a four-channel acquisition system (EMGLab, EMG System do Brasil Ltda, SJC, Brazil) composed of a signal conditioning module, electrodes, an analog band pass filter (20 to 500 Hz) and a common rejection mode ratio of 120 dB. The sampling frequency was 2 kHz and the signal was digitized using an analog-digital converter with 16 bits of resolution. Active bipolar electrodes with 20-fold pre-amplification were used to capture the EMG signals. After cleaning the skin with 70% alcohol to diminish impedance, two disposable, self-adhesive Ag/AgCl electrodes (Noraxon®) were attached to the belly of each muscle in the region of greatest tone, which was determined during the performance of moderate intercuspation[25]. An electrode was positioned on the left wrist of each volunteer to impede the interference of external noise.

The electrical activity of the masseter and anterior temporal muscles was determined under three conditions: i) at rest; ii) during chewing (isotonic contraction) and iii) during maximum intercuspation (MI) (isometric contraction). The signals determined at rest and during chewing were captured with no material placed between the maxillary and mandibular arches. Each volunteer remained seated comfortably on a chair with hand resting on the thighs. Three readings were made under each condition, with a three-minute rest period between readings. Readings were first performed in the resting position and each reading lasted 15 seconds. Readings were then performed during the simulation of habitual chewing (isotonic contraction). Chewing pace was controlled with the use of a metronome set at 60 beats per minute and each reading lasted 15 seconds. The MI readings were then performed. Three 10-second readings were made with no material between the arches. Next, the volunteer performed maximum voluntary clenching (MVC) with folded pieces of Parafilm M®[26] measuring 15 × 35 × 3 mm between the maxillary and mandibular molars bilaterally for five seconds.

Electrical activity of the muscles under the three conditions was analyzed based on the root mean square (RMS) of the amplitude of the EMG signal (expressed in μV). For the resting and chewing conditions, the RMS was calculated for the entire 15-s reading. The first and last seconds of the raw EMG signal were discarded and the RMS was calculated using a moving window of 25 ms with no overlap for the three-second signal. The mean of the window values was used for the analysis. The RMS under each condition was normalized by the largest RMS obtained from the three readings during MVC (μV / μV × 100: % MVC) and expressed as % of MVC. The EMG signals were processed using specific routines developed

in the Matlab 7.1 program (The MathWorks Inc., Natick, Massachusetts, USA).

A gallium-aluminum-arsenide (GaA1As) device (Twin Flex Evolution®, MM Optics) was used for LLLT and sham treatment. Sessions were held in a reserved room with the patient seated and the head positioned on the Frankfurt plane parallel to the floor. The active tip of the laser was covered with disposable plastic wrap (PVC) for the purposes of hygiene and to avoid cross-contamination. The operator wore proper vestments for the session and cleaning of the sites to be irradiated was performed with 70% alcohol.

Twelve LLLT sessions were conducted at a frequency of two sessions per week. The device was calibrated with a wavelength of 780 nm, energy density of 25 J/cm^2, power density of 1.25 mW/cm^2, output power of 50 mW and a 20-second exposure time per point, resulting in a total energy of 1 J per point. The point application method with a conventional tip was used in contact with the skin (beam spot: 0.04 cm^2), following the protocol suggested by Venezian et al.[9] and Carvalho et al.[6] Laser was administered to three points over the masseter muscle (superior, medial and inferior bundles) and one point over the anterior temporal muscle on each side of the face[27]. The same equipment was used for sham treatment, during which sound was emitted, but no energy was delivered.

Due to the fact that the present investigation was a preliminary study for the qualitative evaluation of the laser protocol suggested for administration to adolescents and young adults, the decision was made to perform a descriptive analysis of the variables and qualitative evaluation of the treatment. Qualitative studies have been on the rise in different health fields, especially in recent decades, as evidenced by the number of such articles currently accepted by scientific periodicals. As humans are the object of qualitative research and are subjective, individual, complex beings with an entire universe of reasons and emotions, such studies are rich sources for descriptions of experiences associated with the point of view of the subject of a study, that is, his/her emic aspect.

RESULTS

The EMG data were compared between the initial evaluation and the evaluation after 12 sessions of laser therapy in the two groups: Group 1 −active LLLT; Group 2 −sham LLLT. Increases in mean electrical activity were found during isometric contraction of the anterior temporal muscle in Group 1 from 67.1 to 69.6 on the right side and from 68.4 to 69.3 on the left side. Analyzing the volunteers individually, only three subjects in this group demonstrated a reduction in the activity of this muscle. Reductions in mean electrical activity were found during the isometric contraction of the anterior temporal muscle in Group 2 from 76.2 to 73.0 on the right side and from 79.6 to 71.7 on the left side. Analyzing the volunteers individually, only two subjects in this group demonstrated an increase in the activity of this muscle. Likewise, electrical activity of the right and left masseter muscle (Table 1) increased in Group 1 and decreased in Group 2.

During the chewing activity, increases in mean electrical activity were found in the masticatory muscles between evaluations in Group 1 (right anterior temporal: 37.5 to 38.8; left anterior temporal: 37.0 to 40.1; right masseter: 25.2 to 29.2; left masseter: 26.6 to 32.4), whereas decreases in mean electrical activity were found in the masticatory muscles between evaluations in Group 2 (right anterior temporal: 42.7 to 39.1; left anterior temporal: 46.3 to 39.4; right masseter: 36.9 to 27.1; left masseter: 33.3 to 26.7). Analyzing the volunteers in Group 1 individually, a perceptible reduction in electrical activity was found in two volunteers and a slight reduction was found in two volunteers regarding the right temporal muscle during chewing and a reduction in electrical activity was found in one volunteer regarding the left anterior temporal muscle. In Group 2, reductions in the electrical activity of the right and left temporal muscles were found in five volunteers. Reductions in electrical activity of the right and left masseter muscle were found in four volunteers and one volunteer in Group 1, respectively, whereas reductions in electrical activity of the right and left masseter muscle were found in five and four volunteers in Group 2, respectively.

DISCUSSION

In the present study, a LLLT protocol suggested for the treatment of TMD in adolescents and young adults was evaluated as an alternative to other forms of treatment[13, 19]. For such, the TwinFlex Evolution® GaA1As laser was used at a wavelength of 786.94 nm and output power of 50 mW to induce biological effects in the masticatory muscles and TMJs. Eight points of

Table 1. EMG of right and left masseter (M) muscle during isometric contraction before and after laser therapy

Group	Masseter	Initial (mean ± SD)	Final (mean ± SD)
Group 1 (LLLT; n=9)	Right	49.1 ± 28.5	56.7 ± 19.7
	Left	51.6 ± 28.5	58.8 ± 19.8
Group 2 (sham; n=7)	Right	60.3 ± 26.9	56.5 ± 24.5
	Left	56.6 ± 30.8	46.3 ± 28.1

the masseter and anterior temporal muscles on each side of the face were chosen, as these muscles are directly involved in the chewing process.

Contrary to what was expected, no reduction in mean muscle activity was found in the group submitted to active LLLT in the present investigation. In a previous study, Venezian et al.[9] concluded that, although LLLT did not promote changes in EMG activity of the muscles evaluated, this form of therapy led to a reduction in pain symptoms. Although the action of LLLT on muscle hyperactivity is debatable, the analgesic and inflammatory modulation effects are highlighted. There are reports that LLLT induces vasodilatation, which has a positive effect on muscle pain, specifically pain related to hypoxia. Sancakli et al.[28] found that LLLT was beneficial to managing pain caused by TMD and improving mandibular function due to its analgesic and muscle-relaxing effects. The authors also state that, despite the large body of literature on LLLT, divergent results are found due to differences with regard to the protocols employed in clinical studies (randomized and non-randomized), power intensity, wavelength time and the site of laser application. Such variations hinder a consensus on the best technique for the treatment of TMD.

EMG has many uses in general dentistry for observation purposes as well as diagnostic and therapeutic purposes[29]. EMG is employed to assess and record electrical activity produced by muscles at rest or when functioning. Researchers have also used this method to assist in the diagnosis of TMD. According to Celinski et al.[30], the relationship between pain and decreased muscle strength is the primary aspect used to identify patients with TMD and this aspect can be determined based on EMG activity, especially during tooth clenching. Using EMG analysis, Lauriti et al.[31] demonstrated that the masticatory muscles of adolescents with TMD exhibit a higher EMG signal while at rest and during maximum intercuspation, indicating hyperactivity of these muscles.

TMD has a multifactor etiology and can be associated with numerous clinical conditions, such as poor posture, occlusal alterations, parafunctional habits and psychological factors. Signs and symptoms are found in more than 75% of the population, with a lower prevalence rate among children and higher rates in adolescents and adults[32–34]. The aim of studies involving young patients with TMD is the early diagnosis of the disorder to treat signs and symptoms and prevent the aggravation of the condition[32–35]. Thus, further studies with controlled, standardized protocols are necessary to establish the best method for the diagnosis and treatment of TMD. This preliminary study encourages the use of low-level laser therapy to reduce pain symptoms in patients with TMD and the employment of electromyography as a complementary diagnostic method.

Conflict of interest

Camila Haddad Leal de Godoy declares that she has no conflict of interest. Lara Jansiski Motta declares that she has no conflict of interest. Eugenio Jose Garcia declares that he has no conflict of interest. Kristianne Porta Santos Fernandes declares that she has no conflict of interest. Raquel Agnelli Mesquita-Ferrari declares that she has no conflict of interest. Ravana Sfalcin declares that she has no conflict of interest. Pamella de Barros Motta declares that she has no conflict of interest. Fabiano Politti declares that he has no conflict of interest. Sandra Kalil Bussadori declares that she has no conflict of interest.

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Contributors' statement

Camila Haddad Leal de Godoy participated in the conception and design of the study, data collection and drafting of the present manuscript. Eugenio Jose Garcia, Ravana Sfalcin and Pamella de Barros Motta helped draft the manuscript and participated in data collection. Lara J Motta and Fabiano Politti performed the statistical analyses and contributed to the design of the study. Kristianne P. S. Fernandes and Raquel A Mesquita-Ferrari critically reviewed the manuscript for intellectual content. Sandra K. Bussadori: Dr. Bussadori conceived and coordinated the study and helped draft the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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