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Effects of low-power laser auriculotherapy on the physical and emotional aspects in patients with temporomandibular disorders: A blind, randomized, controlled clinical trial

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ABSTRACT

Objectives: This study evaluated the effects of low-power laser auriculotherapy (LA) on the physical and emotional symptoms of patients with temporomandibular disorders (TMDs), in comparison with occlusal splints (OS).
Design: Randomized, blinded, prospective, non-inferiority clinical trial.
Interventions: The patients received OS (control group) or LA (experimental group).
Main outcome measures: Following the Consolidated Standards of Reporting Trials (CONSORT) guidelines, patients with TMD were evaluated by using axes I and II of the Research Diagnostic Criteria for RDC-TMD. Both intra- and intergroup quantitative variables were analyzed with ANOVA ($p < 0.05$), while qualitative variables were analyzed with the Kruskal–Wallis (intergroup evaluations; $p < 0.05$) or Mann–Whitney tests (intragroup analyses; $p < 0.05$).
Results: OS improved five physical symptoms of TMD (pain in the right temporal muscle, right and left masseter muscles, left joint, and left intraoral region), while LA improved six (jaw functioning; pain in left masseter muscle, right and left joints, and right and left intraoral regions). Similarly, OS improved seven emotional symptoms (degree of depression, degree of non-specific physical symptoms, excluding pain, degree of non-specific physical symptoms including pain, average pain value in the past 6 months, presence of depression, intensity and characteristics of pain, non-specific physical symptoms including pain), while LA improved five (degree of non-specific physical symptoms including pain, presence of depression, intensity and characteristics of pain, non-specific physical symptoms including pain, non-specific physical symptoms excluding pain).
Conclusion: LA improved the physical and emotional symptoms of TMD, with results similar to OS.
Clinical relevance: For the physical and emotional symptoms associated with TMD, LA showed similar outcomes as OS.

1. Introduction

Temporomandibular disorders (TMDs) are a group of clinical disorders that can affect the temporomandibular joint (TMJ), masticatory muscles, and teeth along with their supporting structures. The disorders can have many causes, including trauma, bruxism, hypermobility and abnormal morphology of the joints, and psychosocial factors.[1–4] The prevalence of TMDs in the general population varies from 7% to 10%; 79.5% of patients with TMDs are women.[4] The articular click is the most frequent manifestation of TMDs, while limitation of mouth opening affects 21.3% of patients, muscle pain occurs in 30.7% of cases, and headaches are reported by 46.7% of patients.[4]

Treatment of TMDs is complex, and several therapeutic approaches are available, including occlusal splints (OSs), occlusal adjustment, drugs, and complementary therapies (e.g., acupuncture and auriculotherapy).[1,3] In particular, OSs help reduce masticatory muscle

Abbreviations: AAOP, American Academy of Orofacial Pain; ANOVA, analysis of variance; CONSORT, Consolidated Standards of Reporting Trials; LA, laser auriculotherapy; OS, occlusal splint; RDC/TMD, Research Diagnostic Criteria for Temporomandibular Disorders; SCL-90, Symptoms Checklist-90; TMD, temporomandibular disorders; TMJ, temporomandibular joint; VAS, visual analog scale

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hyperactivity in patients with bruxism or TMDs. They also protect teeth from the attrition and abrasion caused by bruxism and other parafunctional habits,[5–8] and have been used to alter occlusal relationships, redistribute occlusal force, prevent tooth mobility, reduce bruxism, reposition the jaw condyle, and relieve masticatory muscle pain.[5–7,9] Furthermore, several studies have reported that OSs reduce nighttime masticatory muscle activity in patients with bruxism.[6,7,9,10]

With respect to alternative and complementary medicine, auriculotherapy has emerged as an effective alternative for the treatment of both acute and chronic pain, such as headache, muscular and skeletal pain, and pain after third molar removal.[11–14] Auriculotherapy aims to balance bodily functions by using stimuli applied at specific points on the auricular pavilion (auricular acupoints); it is low-cost, relatively non-invasive, and well-accepted by patients. The analgesic effects of auriculotherapy derive from its blockade of nociceptive stimuli in both the central and peripheral nervous systems; stimulation of the auricular acupuncture point activates specific neural centers that promote the release of cortisol, endorphins, dopamine, norepinephrine, and serotonin.[8–17]

More recent studies on auriculotherapy have used low-power lasers, rather than needles, to stimulate auricular acupoints, reducing the invasiveness and pain inherent in the therapeutic process; this facilitates better acceptance by patients.[14,16,18,19] One study used low-power lasers at systemic acupuncture points to evaluate the effects of the treatment on muscle activity in children with bruxism.[8] However, we found no studies that used laser auriculotherapy (LA) as an adjunct treatment for TMDs. Therefore, we conducted a blind, randomized, controlled clinical study to evaluate the effects of low-power LA on the physical and emotional aspects of TMDs, and to compare the effects of low-power LA with those of OSs.

2. Materials and methods

2.1. Patient selection

This randomized, blinded, prospective, non-inferiority clinical trial was conducted between January and December 2015. Assuming a one-sided 5% significance level, a power of 80% in the OS group and a non-inferiority limit of 12% for the experimental group (LA), 10 patients were required for each group.[21] Bearing in mind the estimated losses during follow-up, a total of 40 patients were recruited. The sample was selected from among the pool of primary school teachers in the city Campina da Lagoa, Paraná, Brazil. The experimental design followed the Consolidated Standards of Reporting Trials (CONSORT) statement,[20] Fig. 1, and was registered in the Brazilian Clinical Trials Registry (REBEC) (UTN: U1111-1147-7432). The study protocol was reviewed and accepted by the Charity Evangelical Association of Londrina Ethics Committee on Investigations Involving Human Subjects (CAAE 54732816.1.0000.5696). All patients who met the selection criteria were informed of the objectives, procedures, risks, and benefits of the study; they expressed consent to participate by signing the Terms of Free and Enlightened Consent.

The inclusion criteria were as follows: (1) age ≥18 years; (2) score of ≥3 in the Orofacial Pain and TMD questionnaire of the American Academy of Orofacial Pain (AAOP); and (3) TMD with myofascial pain according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), which has been translated and validated in the Portuguese language for use in the Brazilian population.[22,23]

The exclusion criteria were as follows: (1) non-painful TMD according to the RDC/TMD; (2) previous prosthetic rehabilitation; (3) associated diseases, such as fibromyalgia, facial paralysis, rheumatoid arthritis, mental illness, or cognitive deficits that would impede understanding of some stages of the research; (4) pregnancy; (5) injuries to the external ear; (6) immunocompromised state; (7) coagulopathies; (8) metabolic disease; (9) vascular disease or neoplasia; (10) associated therapies, such as interocclusal appliances, psychotherapy, physiotherapy, orthodontics, or alternative therapies; (11) continuous use of medication (e.g., anxiolytic antidepressants and anticonvulsants); and (12) recent use of medications that interfere with pain perception (e.g., analgesics, anti-inflammatories, and muscle relaxants), with respect to the duration of action of the drug, as described on the package inserts.

2.2. Experimental plan

Based on the inclusion and exclusion criteria, 40 volunteers were ultimately selected (Fig. 1). The patients were then divided into two groups of 20 volunteers (OS control and LA experimental groups) by using the block randomization function (4 × 5) of the Research Randomizer software version 4.0. Patients in the OS group were instructed to use the OS for 8 h daily (overnight), and to return for the first occlusal adjustments after 48 h and 7 days.[6] Patients in the LA group underwent low-power LA (Endofoton; KLD-Biosystems Electronic Equipment, São Paulo, Brazil) by using a 75-W pulsed diode laser emitter (InGaAs\GaAs) with an output power of 50 mW, wavelength of 904 nm, pulse width of 100 ns, peak power of 50 W, and emission area of 0.01 cm^2. The LA was applied by contact at the following points: *shen-men* (1-C), TMJ (43-E), heart (60-CL) (Fig. 2), and the ear of the dominant side of the body.[23] Eight sessions of LA were performed once per week; each auricular acupuncture point received 24 s of laser irradiation at 4 J/cm^2.[18]

2.3. Procedures

Evaluation was performed by using the RDC/TMD to analyze pain, degree of disability related to chronic pain, and degree of depression. Specifically, pain was evaluated subjectively by using a visual analog scale (VAS); the patients were asked to make a mark from 0 to 10 at the point on the VAS that best represented their pain at the time of evaluation, with “0” indicating “no pain” and “10” indicating “worst possible pain.”

Disability related to chronic pain was classified according to pain intensity and associated limitations by using the Graded Chronic Pain Scale: individuals without TMD pain in the previous 6 months were classified as grade 0. Individuals who scored < 50 points on the VAS and < 3 disability points on the Graded Chronic Pain Scale were classified as showing grade I chronic pain (low disability, low pain intensity). Patients were classified as showing grade II chronic pain (low disability, high intensity) when they reported a pain intensity of > 50 i had < 3 points in the disability classification. Grade III chronic pain (high disability, moderate limitation) referred to cases in which patients reported three or four disability points, regardless of pain intensity. Grade IV chronic pain (high disability, severe limitation) was recorded when patients reported five or six disability points, regardless of pain intensity.[24] Depression levels were evaluated as normal, moderate, or severe using the Depression Scale of the Symptoms Checklist-90 (SCL-90).[23–25]

Painful sites were evaluated through muscle and joint palpation according to the axis 1 instructions of the RDC/TMD; the VAS was used, with the patient reporting the intensity of perceived pain from 0 to 10. In the evaluation of extraoral palpation sites, a portable digital dynamometer was used (model DD-500; Instrutherm, São Paulo, Brazil) to ensure that the pressure used for palpation was consistent. This instrument contains a disk-shaped end 1 cm in diameter that applies pressure on the regions of interest. The following muscles were analyzed: masseter (superficial and deep portions), temporal muscle, jaw muscles (style hyoid, digastric, medial pterygoid, and suprahyoid), and intraoral muscles (lateral pterygoid and temporal tendon), which were palpated manually. In addition, the articular region was evaluated (lateral pole of jaw head and posterior ligament).[24,26]

To evaluate vertical extension of the jaw, three measurements were performed: unassisted oral opening without pain, assisted mouth

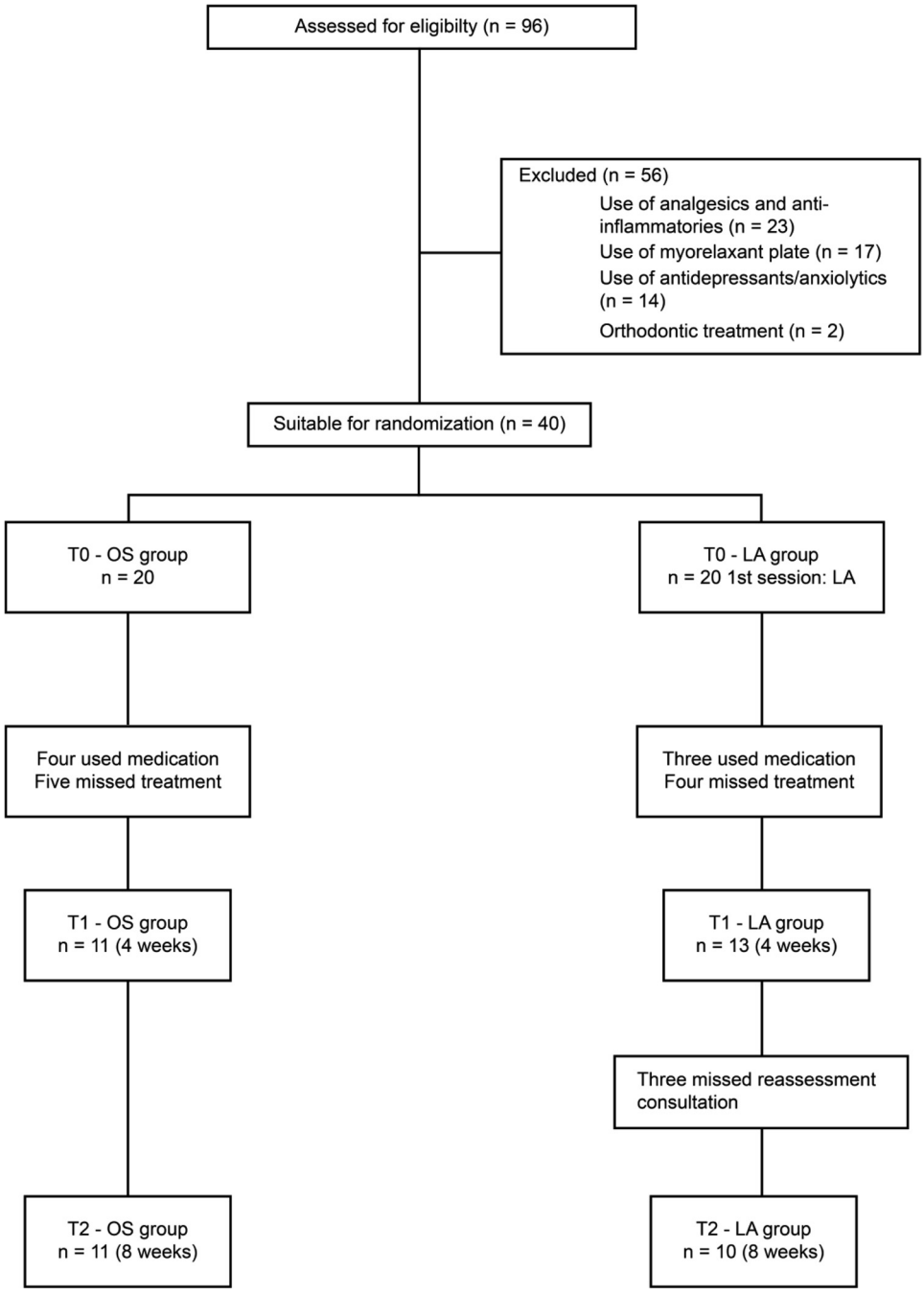

Fig. 1. CONSORT trial flow diagram of the clinical trial. OS: occlusal splint; LA: laser auriculotherapy.

opening without pain, and assisted mouth opening with pain.[24,26] The RDC/TMD and clinical evaluations were always performed by the same blinded researcher, who was uninvolved in the selection of patients, allocation of experimental groups, application of treatment, and analysis of results. The techniques were applied by a single investigator who was uninvolved in data collection. There was no contact among patients in the different groups because they were treated on different days. The participants were evaluated at three different times: immediately before the start of treatment (T0), 4 weeks after starting treatment (T1), and 8 weeks after starting treatment (T2).

2.4. Statistical analyses

Of the 28 variables studied, only three were classified as quantitative: unassisted mouth opening without pain, assisted mouth opening without pain, and assisted mouth opening with pain. For these variables, the Shapiro-Wilk normality test was applied, and normal distributions were observed. For the intergroup and intragroup analyses of these three variables, one-way ANOVA was applied, followed by the Tukey test ($p < 0.05$).

The following 25 variables were classified as ordinal qualitative: jaw function limitations, right temporal pain, left temporal pain, right masseter pain, left masseter pain, right jaw pain, left jaw pain, right joint pain, left joint pain, right intraoral pain, left intraoral pain, degree of chronic pain, degree of depression, degree of non-specific physical symptoms including pain, degree of non-specific physical symptoms excluding pain, pain at time of assessment, worst pain in the past 6 months, average value of all pain in the past 6 months, how facial pain interferes with daily life, how facial pain interferes with work, presence of depression, intensity and characteristics of pain, non-specific

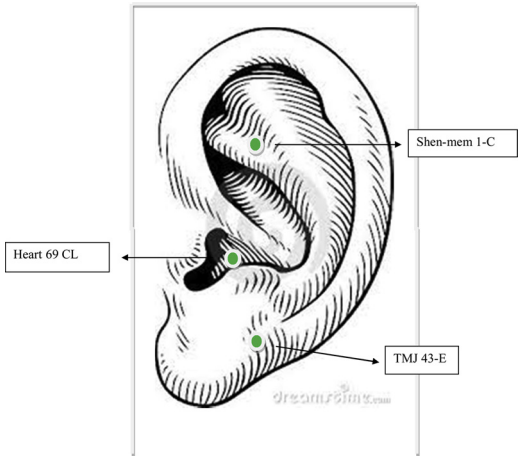

Fig. 2. Anatomical localization of auricular acupoints.

symptoms including pain, non-specific symptoms excluding pain. These variables were assessed with the Kruskal–Wallis test, with the Dunn post-test applied for intragroup analysis ($p < 0.05$) and the Mann–Whitney test applied for intergroup analysis ($p < 0.05$). At the end of the experiment, the chi-squared test ($p < 0.05$) was applied to compare the two groups with respect to the number of variables that had shown improvement in the scores. In this study, in order to ensure more effective preservation of the integrity of randomization, the statistical analysis was conducted in a per-protocol model and not an intention-to-treat model because of the low number of subjects in the final study sample.

3. Results

Although this study began with 40 volunteers divided equally into two groups, at the end of the follow-up period, data could only be analyzed for 21 volunteers in the two groups (Fig. 1). Thus, a total of 21 women were treated and monitored during the 8-week evaluation; they were divided into two groups: OS (n = 11; average age, 43.63 years) and LA (n = 10; average age, 47.5 years).

3.1. Physical aspects

Intergroup analysis revealed that the groups were similar at baseline (T0; $p > 0.05$; Table 1). Intragroup analysis revealed that, of the 14 variables related to the physical aspects of TMDs, four did not exhibit statistically significant results in either group: this included three variables related to mouth opening amplitude and the right jaw palpation variable (Table 2).

Thus, in the OS group, five variables showed significant improvement at T2 (right temporal muscle pain, right and left masseter muscle pain, left joint pain, and left intraoral pain). In the LA group, six variables showed significant improvement at T2 (degree of jaw functioning, left masseter muscle pain, right and left joint pain, and right and left intraoral pain; Table 2).

3.2. Emotional aspects

Intergroup evaluation revealed that the groups evaluated were similar ($p > 0.05$) at T0 (Table 3). Intragroup analysis showed that in the OS group, seven variables exhibited significant improvement at T2 (degree of depression, degree of non-specific physical symptoms excluding pain, degree of non-specific physical symptoms including pain, average value of all pain in the past 6 months, depression, intensity and characteristics of pain, and non-specific physical symptoms including pain). In the LA group, significant improvements were observed in five variables at T2 (degree of non-specific physical symptoms including pain, depression, intensity and characteristics of pain, non-specific physical symptoms including pain, and non-specific physical symptoms excluding pain; Table 4).

Table 1
Physical symptoms: intergroup analysis at baseline (T0).

Variables/Groups	Median ± interquartile deviation (score)		
	OS group	LA group	p value
Func	5.00 ± 2.00	4.50 ± 2.50	0.7212
R Temp	1.00 ± 0.83	0.83 ± 1.00	0.2239
L Temp	2.00 ± 1.17	1.00 ± 0.83	0.0935
R Mas	2.00 ± 0.83	2,17 ± 1.67	0.6937
L Mas	2.33 ± 1.12	2.33 ± 1.49	0.9144
R Jaw	1.50 ± 2.00	1.00 ± 1.75	0.5473
L Jaw	1.50 ± 1.00	1.00 ± 0.47	0.6178
R Joint	1.50 ± 1.00	1.75 ± 1.25	0.9429
L Joint	2.00 ± 1.50	1.75 ± 1.62	0.5654
R Int	3.00 ± 0.75	2.50 ± 0.37	0.4450
L Int	3.00 ± 0.25	2.50 ± 0.50	0.1429
Variables/Groups	Mean ± standard deviation (mm)		
	OS group	LA group	p value
UnassOpP-	32.82 ± 7.08	33.70 ± 7.20	0.7769
AssOpPain-	47.54 ± 8.59	47.70 ± 6.60	0.8185
AssOpPain+	52.27 ± 6.28	53.00 ± 6.50	0.7930

$p > 0.05$: absence of significant differences.
OS: occlusal splint; LA: laser auriculotherapy; Func: limitations related to jaw functioning; L, left; R, right; Temp: temporal; Mas: masseter; Int: intraoral; UnassOpPain-: unassisted mouth opening and without pain; AssOpPain-: assisted mouth opening and without pain; AssOpPain+: assisted mouth opening and with pain.

3.3. Analysis of therapies used

The chi-squared test revealed that the number of variables exhibiting significantly different results after treatment was similar between the two groups, demonstrating that the therapies yielded similar results with respect to both physical and emotional aspects of TMDs

4. Discussion

Evaluations of TMDs are important due to the prevalence and debilitating effects of these conditions, which are both physical and psychosocial in nature. Thus, it is essential that researchers use internationally standardized criteria that are validated in the language and culture of the study population (e.g., the AAOP questionnaire and the RDC-TMD), because these facilitate clinicians' understanding of the etiology, somatic manifestations, and psychosomatic characteristics of TMDs. They can also be used to compare different studies performed around the world.[1,10,23]

Among treatments that can provide relief from TMD complaints, OSs are particularly effective[1,2,6–10,15] because they protect the dental structures, promote pain relief in the masticatory muscles and TMJ, improve the position of the jaw condyle, and redistribute the occlusal force, promoting a better physiological musculoskeletal relationship in the stomatognathic system.[1,6–1015,16] These clinical benefits of OSs corroborate the results of the present study, whereby patients in the OS group showed improvements in both physical and emotional symptoms of TMDs, as shown previously.[1,6,7,9]

With regard to the use of auriculotherapy as a complementary treatment, several studies have revealed that it shows analgesic action in a number of clinical situations, including knee surgery, third molar removal, and chronic musculoskeletal pain (e.g., TMDs). Auriculotherapy is easily performed, provides symptomatic relief, and

Table 2
Intragroup analysis of physical symptoms.

	Median ± interquartile deviation (score)					
	OS group			LA group		
Variables	T0	T1	T2	T0	T1	T2
Func	5.00 ± 2.00[a]	2.00 ± 2.50 [a]	2.00 ± 2.50 [a]	4.50 ± 2.50[a]	3.00 ± 4.00[ab]	0.50 ± 1.75[b]
R Temp	1.00 ± 0.83[a]	0.66 ± 0.83[b]	0.66 ± 0.33[b]	0.83 ± 1.00 [a]	0.66 ± 0.67 [a]	0.00 ± 0.58 [a]
L Temp	2.00 ± 1.17[a]	0.33 ± 0.49[b]	0.66 ± 0.83[ab]	1.00 ± 0.83 [a]	0.67 ± 1.16 [a]	0.17 ± 0.33 [a]
R Mas	2.00 ± 0.83[a]	1.66 ± 1.00[a]	0.66 ± 1.16[b]	2.17 ± 1.67 [a]	1.17 ± 1.16 [a]	1.00 ± 0.67 [a]
L Mas	2.33 ± 1.16[a]	1.33 ± 1.16[ab]	1.00 ± 1.16[b]	2.33 ± 1.49[a]	1.00 ± 1.50[ab]	0.66 ± 1.67[b]
R Jaw	1.50 ± 2.00 [a]	0.50 ± 1.50 [a]	0.00 ± 1.00 [a]	1.00 ± 1.75 [a]	1.00 ± 1.29 [a]	0.00 ± 0.87 [a]
L Jaw	1.50 ± 1.00 [a]	0.50 ± 0.25 [a]	1.00 ± 0.00 [a]	1.00 ± 0.47 [a]	1.00 ± 0.75 [a]	0.00 ± 0.00 [a]
R Joint	1.50 ± 1.00 [a]	1.50 ± 1.25 [a]	0.50 ± 1.75 [a]	1.75 ± 1.25[a]	1.00 ± 0.87[ab]	0.50 ± 0.75[b]
L Joint	2.00 ± 1.50[a]	1.00 ± 1.50[b]	1.00 ± 1.50[b]	1.75 ± 1.62[a]	1.00 ± 1.87[ab]	0.50 ± 1.00[b]
R Int	3.00 ± 0.75 [a]	2.50 ± 0.75 [a]	2.50 ± 1.50 [a]	2.50 ± 0.37[a]	1.75 ± 1.25[ab]	1.50 ± 0.87[b]
L Int	3.00 ± 0.25[a]	2.50 ± 1.00[b]	2.50 ± 1.50[b]	2.50 ± 0.50[a]	2.25 ± 1.00[ab]	1.50 ± 1.25[b]
	Mean ± standard deviation in OS group (mm)			Mean ± standard deviation in LA group (mm)		
UnassOpP-	47.54 ± 8.59[a]	48.54 ± 7.22[a]	49.00 ± 6.93[a]	47.70 ± 6.60[a]	48.60 ± 5.70[a]	48.10 ± 3.90[a]
AssOpP-	32.82 ± 7.08[a]	39.36 ± 9.00[a]	39.27 ± 9.90[a]	33.70 ± 7.20[a]	37.30 ± 8.70[a]	39.50 ± 7.70[a]
AssOpP +	52.27 ± 6.28[a]	53.00 ± 6.59[a]	52.82 ± 5.74[a]	53.00 ± 6.50[a]	53.60 ± 5.70[a]	53.70 ± 4.30[a]

Different superscript letters (a, b) within the same line indicate a significant difference in evaluation time ($p < 0.05$).
OS: occlusal splint; LA: laser auriculotherapy; Func: limitations related to jaw functioning; L: left; R: right; Temp: temporal; Mas: masseter; Int: intraoral; UnassOpPain-: unassisted mouth opening and without pain; AssOpPain-: assisted mouth opening and without pain; AssOpPain + : assisted mouth opening and with pain.

Table 3
Intergroup analysis of the emotional symptoms at T0 (baseline) median ± interquartile deviation (score).

Variables/Groups	OS group	LA group	p value
DofCPA	2.00 ± 0.75	2.00 ± 0.00	0.1699
DofDep	3.00 ± 0.00	2.00 ± 1.00	0.0991
DofPSP-	3.00 ± 0.00	3.00 ± 0.00	0.9455
DofPSP +	3.00 ± 0.00	3.00 ± 0.00	0.0612
VAS7	4.00 ± 5.00	5.00 ± 2.50	0.7487
VAS8	9.00 ± 2.00	10.00 ± 1.00	0.3493
VAS9	6.00 ± 2.00	7.00 ± 1.75	0.4960
VAS11	3.00 ± 6.00	5.00 ± 4.50	0.4542
VAS12	5.00 ± 6.50	6.50 ± 9.00	0.2428
VAS13	5.00 ± 5.50	7.00 ± 4.75	0.1161
Dep	1.75 ± 0.47	0.92 ± 0.59	0.1582
ICP	68.30 ± 36.65	71.65 ± 13.27	0.8306
NSSP +	2.00 ± 0.79	1.91 ± 0.36	0.5962
NSSP-	1.85 ± 0.50	1.64 ± 0.75	0.6205

$p > 0.05$: absence of significant differences.
OS: occlusal splint; LA: laser auriculotherapy; DofCPA: degree of chronic pain assessed; DofDep: degree of depression; DofPSP-: degree of non-specific physical symptoms excluding pain; DofPSP + : degree of non-specific physical symptoms including pain; VAS7: pain at the time of assessment; VAS8: worse pain in the last 6 months; VAS9: average value of all pains in the past 6 months; VAS11: pain interfering in daily life; VAS12: pain interfering in social and leisure activities; VAS13: pain interfering in the ability to work; Dep: presence of depression; ICP: intensity and characteristic of pain; NSSP-: non-specific symptoms excluding pain; NSSP + : non-specific symptoms including pain.

is well-accepted by patients.[1,8,10,13–17,27] Auriculotherapy acts by stimulating acupoints that appear to promote the blockage of nociceptive stimuli by releasing cortisol, endorphins, and serotonins, thus reducing or eliminating pain[6,7]; this is consistent with the results in the LA group in the present study.

Two previous studies applied traditional auriculotherapy with needles and mustard seeds to treat TMDs.[10,15] However, the authors used different combinations of acupoints and different follow-up times, demonstrating that no therapeutic protocol has yet been defined for the treatment of TMDs. Nonetheless, both authors cited the benefits of auriculotherapy as an alternative technique for the treatment of TMDs, corroborating the results of the present study; herein, low-power LA was shown to produce significant improvements in both physical and emotional aspects of TMDs.

Furthermore, the present study showed that OSs and low-power LA produced similar results in the treatment of physical and emotional aspects of TMDs. However, with respect to the physical aspects of TMDs, these treatments appeared to have distinct effects on specific structures. Specifically, OSs appeared to confer improvements in left temporal muscle pain, masseter muscle pain on both sides, left joint pain, and left intraoral pain (lateral pterygoid muscle); this may have occurred because OSs relieve muscular pain by reducing muscular hyperactivity, redistributing occlusal force, and repositioning the jaw condyle.[6,7] In contrast, the LA group showed improvements in jaw functioning, left masseter muscle pain, joint pain (on both sides), and intraoral (lateral pterygoid muscle) pain on both sides, likely because of the stimulation of auricular acupoints, which promotes analgesic blockade through the release of endogenous opioids in the treated region.[8,10,13–17,25,27] In the present study, stimulation was performed at the TMJ point, as well as at the *shen-men* and heart points to treat the emotional aspects of TMDs. The findings suggest that stimulation of the chosen points promoted relief of TMJ pain on both sides, as well as in the lateral pterygoid region; this likely promoted improvements in jaw function.

Comparing the effects of the OS and LA on the emotional aspects of TMDs, the two techniques showed similar outcomes with respect to the groups evaluated, although different results were observed with respect to the variables that showed significant improvements. Specifically, in the OS group, the following three variables showed improvements that were superior to those in the LA group: degree of depression, degree of non-specific physical symptoms excluding pain, and average value of all pain in the past 6 months. This difference may have occurred because patients in the OS group used their mouth guard daily for 8 h, while those in the LA group received treatment only once per week. Patients in the LA group exhibited significant improvements in four variables for which OSs were also effective: degree of non-specific physical symptoms including pain, depression, intensity and characteristics of pain, and non-specific physical symptoms including pain. These improvements in emotional aspects can be attributed to the stimulation of the *shen-men* and heart points, which influence the depressive state through vagal stimulation.[25]

Table 4
Intragroup analysis of emotional symptoms, median ± interquartile deviation (score).

Variables	OS group			LA group		
	T0	T1	T2	T0	T1	T2
DofCPA	2.00 ± 0.75[a]	1.50 ± 1.00 [a]	1.00 ± 1.00 [a]	2.00 ± 0.00[a]	2.00 ± 1.00[a]	2.00 ± 1.75[a]
DofDep	3.00 ± 0.00[a]	2.00 ± 1.00[ab]	2.00 ± 1.00[b]	2.00 ± 1.00[a]	1.50 ± 1.75[a]	1.50 ± 1.00[a]
DofPSP-	3.00 ± 0.00[a]	2.00 ± 1.50[ab]	2.00 ± 1.00[b]	3.00 ± 0.00[a]	2.00 ± 1.50[a]	1.50 ± 2.00[a]
DofPSP +	3.00 ± 0.00[a]	3.00 ± 1.00[ab]	2.00 ± 1.00[b]	3.00 ± 0.00[a]	2.00 ± 0.00[ab]	2.00 ± 1.75[b]
VAS7	4.00 ± 5.00[a]	2.50 ± 3.75[a]	0.00 ± 1.00[a]	5.00 ± 2.50[a]	1.00 ± 5.00[a]	0.00 ± 0.00[a]
VAS8	9.00 ± 2.00[a]	8.00 ± 4.00[a]	7.00 ± 3.50[a]	10.00 ± 1.00[a]	10.00 ± 0.75[a]	10.00 ± 2.50[a]
VAS9	6.00 ± 2.00[a]	5.00 ± 2.00[ab]	3.00 ± 3.00[b]	7.00 ± 1.75[a]	6.50 ± 3.00[a]	7.50 ± 4.00[a]
VAS11	3.00 ± 6.00[a]	1.00 ± 4.50[a]	0.00 ± 3.00[a]	5.00 ± 4.50[a]	4.50 ± 6.00[a]	5.00 ± 5.75[a]
VAS12	5.00 ± 6.50[a]	0.00 ± 5.50[a]	0.00 ± 2.50[a]	6.50 ± 9.00[a]	5.50 ± 7.00[a]	2.00 ± 5.00[a]
VAS13	5.00 ± 5.50[a]	0.00 ± 5.50[a]	0.00 ± 3.00[a]	7.00 ± 4.75[a]	5.00 ± 5.00[a]	5.00 ± 0.75[a]
Dep	1.75 ± 0,47[a]	0.85 ± 1,02[ab]	0.50 ± 0.55[b]	0.92 ± 0.59[a]	0.57 ± 0.86[ab]	0.47 ± 0.52[b]
ICP	68.30 ± 36.65[a]	51.30 ± 28.35[ab]	33.30 ± 17.50[b]	71.65 ± 13.27[a]	66.60 ± 21.65[ab]	58.30 ± 22.52[b]
NSSP +	2.00 ± 0.79[a]	1.41 ± 1.21[ab]	0.75 ± 0.46[b]	1.91 ± 0.36[a]	0.75 ± 0.31[b]	0.83 ± 0.65[b]
NSSP-	1.85 ± 0.50[a]	1.00 ± 1.35[a]	0.57 ± 0.50[a]	1.64 ± 0.75[a]	0.64 ± 0.54[ab]	0.35 ± 1.29[b]

Statistically significant difference; different superscript letters (a, b) within the same line indicate a significant difference in evaluation time, $p < 0.05$.
OS: occlusal splint; LA: laser auriculotherapy; DofCPA: degree of chronic pain assessed; DofDep: degree of depression; DofPSP-: degree of non-specific physical symptoms excluding pain; DofPSP+: degree of non-specific physical symptoms including pain; VAS7: pain at the time of assessment; VAS8: worse pain in the last 6 months; VAS9: average value of all pains in the past 6 months; VAS11: pain interfering in daily life; VAS12: pain interfering in social and leisure activities; VAS13: pain interfering in the ability to work; Dep: presence of depression; ICP: intensity and characteristic of pain; NSSP-: non-specific symptoms excluding pain; NSSP+: non-specific symptoms including pain.

This controlled clinical study of TMDs demonstrates the intrinsic difficulties of this type of pathology, which has a multifactorial etiology. A primary challenge in this study was the difficulty of composing a homogeneous sample of volunteers with rigid criteria. However, this facilitated better alignment of the results with the specific clinical reality of the patients who present at dental offices. Moreover, because the pathology involves various symptoms associated with pain of various etiologies, patient loss during follow-up was quite high due to the presence of other health conditions that required pharmacological intervention, such as the use of painkillers and anti-inflammatories. Thus, the external validity of the results should be assessed in the light of restrictions specific to the characteristics of the population studied.

Another limitation of this study was the number of return consultations required for evaluation of each type of treatment. For example, for treatment by means of splint, two return consultations were performed for occlusal adjustment and another two assessment consultations were performed after installation (T1 and T2); for the treatment with auriculotherapy, return consultations were performed weekly, totaling eight sessions, including the T1 and T2 evaluations that occurred on the same day that patients returned for needle insertion in the acupoints. Despite this limitation of the study, it is particularly important to consider that this difference in the number of return consultations is intrinsic to the evaluated treatments; therefore, it was not possible for patients to attend a similar number of consultations for both techniques, because the techniques studied would not be performed properly. However, evaluations at T0, T1, and T2 always occurred at the same time when comparing the two techniques. In addition, it was not possible to include a placebo group in this study because the local ethics committee did not understand the requirement for this group; the most frequently used treatment in the dental office is the splint, and thus the benefit of subjecting patients to a placebo treatment did not justify their inclusion in experimental groups. In the present study, LA improved both physical and emotional symptoms in patients with TMD, in a manner similar to the OS method. However, there were differences in the structures or pain points affected. Therefore, we believe that the combination of the OS and LA techniques may confer greater improvements in patients with TMDs, relative to the use of either technique alone. Notably, controlled studies should be performed to evaluate patients' response to combinations of these techniques.

In summary, in the present study, low-power LA improved both physical and emotional symptoms in patients with TMDs; the treatment outcomes were similar to those in patients treated with an OS.

Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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