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ORIGINAL ARTICLE

Laser treatment for temporomandibular disorder: a randomized controlled clinical trial

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Abstract

This study aimed to assess the impact of photobiomodulation therapy (PBMT) using low-level laser therapy, an occlusal splint (OS), and their combined application (OSL) on symptoms of muscular temporomandibular disorder (TMD) through a randomized clinical trial. Participants diagnosed with muscular TMD following the Diagnostic Criteria for TMD guidelines were allocated to three groups: OS, L, and OSL. The OS and OSL groups utilized the device during sleep, while PBMT (3 J/cm² per point) was applied to the L and OSL groups in 5 weekly sessions employing infrared light (808 nm). Pain levels were evaluated using the visual analogue scale (VAS), mandibular mobility was assessed via maximum unassisted mouth opening, and quality of life was measured using the Oral Health Impact Profile (OHIP-14). A total of 99 participants (OS: $n=34$, L: $n=32$, OSL: $n=33$), including 80 women and 19 men with an average age of 31.54 ± 10.39 years, were enrolled. Significant pain reduction occurred in the L and OSL groups ($p<0.05$), with the OSL group demonstrating higher effectiveness compared to the OS group within the initial two weeks ($p<0.05$). Post-treatment, the L and OSL groups exhibited notable improvements in mandibular mobility, except during the final session ($p<0.05$). All groups reported enhanced quality of life, with the L group achieving higher scores than the OS and OSL groups during reassessment ($p<0.05$). Laser therapy effectively treated muscular TMD, both as a standalone therapy and in combination with the OS, particularly for immediate pain relief. The combination of therapies was important for maintaining stable symptom control over time.

Keywords Temporomandibular joint disorder · Low-level laser therapy · Occlusal splint · Quality of life · Conservative treatment

Introduction

Temporomandibular disorder (TMD) encompasses various conditions that involve the masticatory muscles, the temporomandibular joint (TMJ), and associated anatomical structures [1, 2]. It is estimated to affect about 31% of adults and older individuals, as well as 11% of pediatric and adolescent populations [3]. The etiology of TMD involves physical, psychological, and social factors, aligning with the biopsychosocial model [4, 5]. Musculoskeletal pain in the lateral face, head, and neck is a primary symptom of TMD, which can alter motor behavior and restrict mandibular movements [6–9]. Other common symptoms include joint sounds, tinnitus, and a sensation of ear fullness, all of which can significantly impact an individual's quality of life [8–10].

The Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) serves as a crucial framework for precise diagnosis, classifying TMD into myogenic, arthrogenic, or mixed categories, while simultaneously considering the disorder's physical and psychosocial aspects [3, 11–13]. Because of the multifactorial nature of TMD, conservative

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therapies are the preferred treatment [10, 14]. These therapies include an occlusal splint (OS), cognitive-behavioral therapy, pharmacological treatments, transcutaneous electrical nerve stimulation, acupuncture, manual therapies, ultrasound, and low-level laser therapy (PBMT) [1, 5, 12].

The OS is one of the most well-documented and commonly used treatments for TMD [12, 15, 16]. In the modified mixed technique, the mandible's exact position is determined through direct muscle action without the need for plaster model mounting on an articulator, allowing for same-day installation [17]. However, the effectiveness of OS application varies and depends on patient adherence [15, 18].

The PBMT is an alternative treatment known for its analgesic, anti-inflammatory, and regenerative properties, which promote muscle relaxation and alleviate trigger points [1, 19, 20]. These effects have spurred a growing interest in investigating the efficacy of PBMT over recent years. However, these studies frequently exhibit inconsistencies stemming from variations in parameters, inadequate standardization, and limited sample sizes [9, 21]. Consequently, stronger and more comprehensive evidence is required to confirm its therapeutic potential for TMD [11, 22].

Given the limited studies describing precise protocols and the combination of conservative therapies, this study aimed to evaluate the isolated and combined use of an OS (using the modified mixed fabrication technique) and PBMT for controlling pain, improving mandibular mobility, and enhancing oral health-related quality of life in patients with muscular TMD.

Methodology

Study design

This blinded, controlled, randomized clinical study used a parallel design and followed the CONSORT guidelines for clinical trials (NCT05989217 Clinical Trials Protocol registration). The study protocol was reviewed and approved by the Human Research Ethics Committee at UNIFAL-MG (protocol no. 66265922.7.0000.5142). In accordance with the guidelines of the National Health Council, all participants were thoroughly informed about the study's details and provided their written consent prior to participation.

Participants were assigned to three groups: the OS Group, receiving conventional occlusal splint treatment (control group); the L Group, undergoing PBMT with low-level laser therapy; and the OSL Group, receiving a combination of both therapies (Table 1).

Table 1 Distribution of study groups

Group	Therapy
OS	Occlusal Splint
L	Laser
OSL	Occlusal Splint + Laser

Participants

Eligible participants were adults presenting with muscular TMD as diagnosed using the DC/TMD Axis 1 [23]. These participants were screened at the TMD Clinic of the School of Dentistry at UNIFAL-MG, where therapeutic procedures and data collection were conducted between April and November 2023.

Inclusion criteria encompassed those with pain in the TMJ or masticatory region, with or without limited mouth opening, and possessing functional occlusion. Participants were excluded if they presented conditions like congenital TMJ anomalies, ongoing orthodontic treatments, severe psychiatric disorders, or recent trauma.

Interventions/therapies

OS group

Participants allocated to this group received the same type of OS, which served as a stabilization splint [16, 18, 24]. The splints, designed as flat surface bite plate, were fabricated using the modified simplified mixed technique [17]. This technique allows for quick fabrication and installation, reducing both laboratory steps and costs. The splint was made for the maxillary arch from an acetate plate moulded on a plaster model and customized with acrylic resin.

After the splint was installed and adjusted, the participants were instructed to wear it every night during sleep. Weekly follow-up appointments were conducted for 4 weeks.

Laser (L) group

The application protocol followed a clinical study focusing on specific TMD points [25]. Received PBMT targeting predefined TMD points using a laser emitting infrared light (808 nm). Applications included trigger points and anatomical regions such as the masseter and temporal muscles (Fig. 1).

The equipment used was the Laser Therapy EC (DMC, São Carlos), and the parameters for the applications are detailed in Table 2.

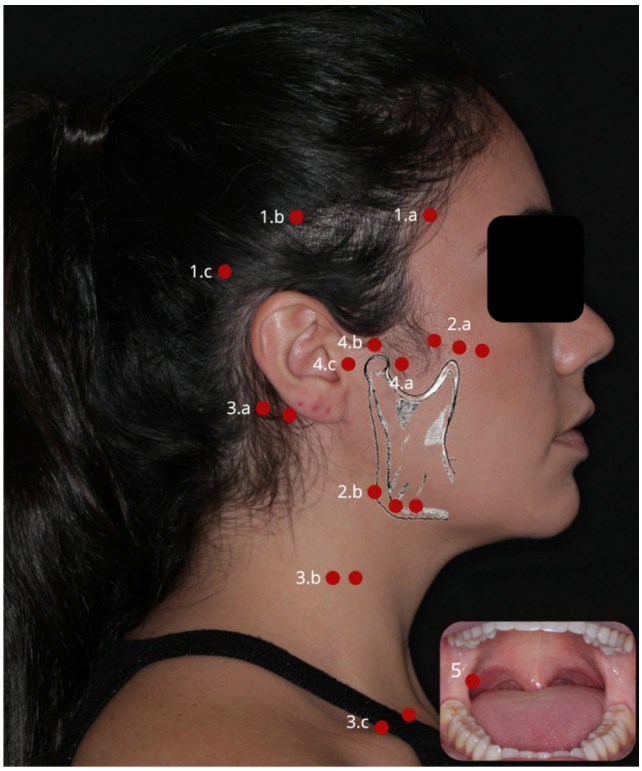

Fig. 1 Predefined areas of laser application. (1) Temporal muscle: anterior muscle bundle (1**a**), middle muscle bundle (1**b**) and posterior muscle region (1**c**); (2) Masseter muscle: three at the origin (2**a**) and three at the insertion (2**b**); (3) Sternocleidomastoid muscle: two at the muscle insertion (3**a**), two in the middle portion (3**b**), and two at the origin (3**c**); (4) TMJ: one at the anterior part of the TMJ (4**a**), one at the most superior portion (4**b**) and one at the most posterior part of the TMJ region (4**c**). (5) Medial pterygoid muscle: one point, located medially behind the retromolar triangle

Table 2 Parameters for laser applications

Parameter	Value	Unit
Device Model	Laser Therapy EC, DMC	-
Wavelength	808	nm
Power Output	100	nW
Energy Density	105	J/cm^2
Spot Area	0.028	cm^2
Energy per Point	3	J
Frequency of Application	1 application per week	-
Therapy duration	4	weeks

OS + L (OSL) group

This group received the combined therapies over the same period as the other groups, following the same application and evaluation protocols.

Outcomes

The study participants were evaluated before and after the therapies at weeks 0, 2, 4, and 12. The primary outcome of this study was spontaneous pain measured using the VAS. The other parameters described were considered secondary outcomes.

The following assessments were performed.

Visual analogue scale (VAS)

The VAS scale was employed to measure spontaneous pain in the TMJ and/or masticatory muscles, whether at rest or during palpation. This scale consists of a 10-cm line, where the left endpoint represents the absence of pain and the right endpoint denotes the most intense pain imaginable [26].

Pain-Free Mouth Opening

This measurement was defined as the greatest distance a participant could open their mouth without pain, determined by the space between the incisal edges of the upper and lower central incisors.

Oral health impact profile (OHIP-14)

The impact of oral health on quality of life was assessed using the OHIP-14 questionnaire, developed by Slade, in its translated and validated version for Brazilian Portuguese [27].

The primary outcome of this study was spontaneous pain in the TMJ and/or masticatory muscles, measured using the VAS. The other parameters described were considered secondary outcomes.

Sample size

The sample size for this study was calculated using G*Power software version 3.1.9.4, based on the work of Ekici, with the VAS for pain following TMD treatment among different experimental groups as the primary variable [28]. The mean difference between assessment periods after 12 weeks of follow-up was used, with an effect size of $F = 0.2879730$. In line with the study's objective, analysis of variance (ANOVA) for repeated measures between factors was applied, considering three experimental groups and five assessment points. A sample size of 96 participants (32 per group) was determined to be sufficient for conducting statistical tests with a type I error of 0.05 and a power (β) of > 0.90.

Randomization

The participants ($n = 99$) were assigned to one of three groups (OS: $n = 34$, L: $n = 32$, OSL: $n = 33$) using a randomization program (https://www.sealedenvelope.com). One

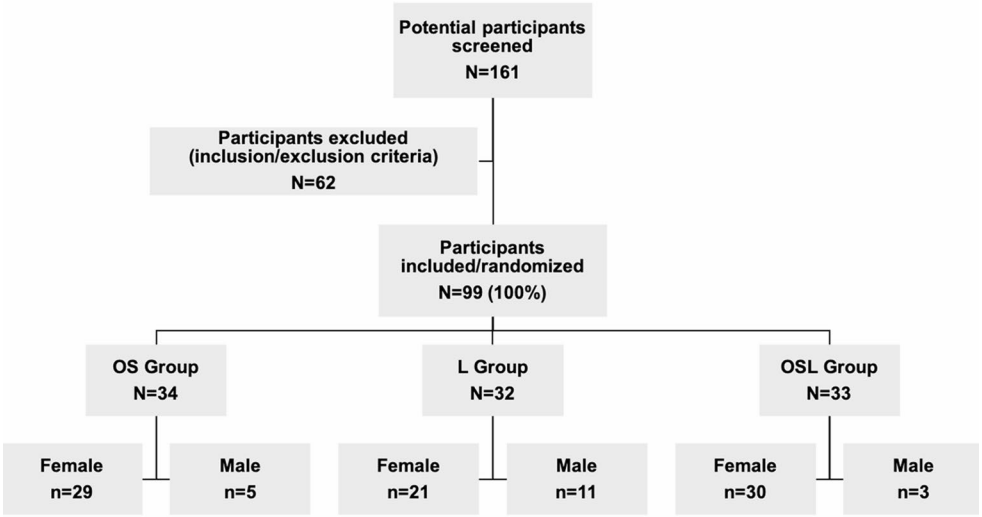

Fig. 2 Flow chart of the study. OS: occlusal splint, L: laser, OSL: occlusal splint + laser, N/n: number of participants

researcher (MFHD), who was not involved in the clinical stages, was responsible for the randomization, allocation, and preparation of the envelopes corresponding to the treatment for each participant.

Blinding

The participants were not informed about the specific meaning of each envelope. All therapies were administered by the research team and conducted by the same researcher, who was aware of the participants' treatment allocations. However, evaluations were conducted by a clinician who remained unaware of the group allocations, ensuring unbiased assessments.

Statistical analysis

Data obtained from the demographic questionnaire, VAS, mouth opening measurements, and OHIP-14 were subjected to the Kolmogorov–Smirnov test to assess normality. Additionally, tests for homoscedasticity and sphericity were performed before conducting the analysis of variance. One-way ANOVA, complemented by Tukey's post hoc test, was used to compare the participants' ages, while the binomial chi-square test was used to analyze the sex distribution. Two-way ANOVA, complemented by Šídák's test, was applied for intragroup comparisons, while Tukey's test was used for intergroup comparisons. All tests were conducted with a 5% significance level using GraphPad Prism 9.5 (GraphPad Software, San Diego, CA, USA).

Table 3 Demographic data

	OS	L	OSL
N	($n=34$)	($n=32$)	($n=33$)
Age			
Mean ± SD	33.12 ± 11.13[a]	32.66 ± 10.09[a]	28.82 ± 9.62[a]
Gender			
Female (%)	29 (85.29)*	21 (65.62)	30 (90.90)*

OS: occlusal splint, L: laser, OSL: occlusal splint + laser, N: number of participants, SD: standard deviation. *Statistically significant intragroup differences between participant sex ($p<0.05$)– binomial chi-square test. Different letters indicate significant differences between groups ($p<0.05$)– one-way ANOVA complemented by Tukey's test

Results

Demographic data

Out of 161 screened individuals, 99 participants met the eligibility criteria (Fig. 2), with an average age of 31.54 ± 10.39 years. Female participants were more prevalent in the OS (85.29%) and OSL (90.90%) groups compared to male participants ($p<0.05$). There were no significant differences in baseline demographics among the groups (Table 3).

Pain (VAS)

The assessment of self-reported pain using the VAS showed no significant difference among the three groups (OS, L, and OSL) at the start of treatment (Week 0– pretreatment; $p>0.05$). After the first treatment session (post-treatment–Week 0), the L group (1.781, $p<0.0001$) and the OSL group (1.485, $p=0.0002$) experienced significant reductions in pain scores compared with the pretreatment levels, with the OSL group demonstrating superior pain reduction compared with the OS group during this period ($p<0.05$).

At Week 2, the OSL group continued to show superior pain reduction compared with the OS group ($p<0.05$), consistent with earlier findings. Significant reductions in pain were also observed between pre- and post-treatment for the L group (mean reduction: 1.594, $p<0.0001$) and the OSL group (mean reduction: 1.063, $p=0.0011$). However, by Week 4, there were no statistically significant differences in pain reduction between the groups post-treatment ($p>0.05$). Despite this, both the L group (mean reduction: 0.9375, $p=0.0002$) and the OSL group (mean reduction: 1.091, $p<0.0001$) continued to show significant decreases in self-reported pain compared with pretreatment levels.

Finally, during the reassessment at 12 weeks, participants in the L group reported higher self-reported pain scores than those in the OS and OSL groups. A statistically significant difference was observed for the OS group, which showed the lowest scores ($p<0.05$) (Fig. 3).

It is noteworthy that all three treatment modalities evaluated promoted a reduction in self-reported pain between the pretreatment session at Week 0 and the post-treatment sessions at Weeks 4 and 12 ($p<0.05$), with the most significant mean difference observed in the OS group after 12 weeks (Fig. 4).

Mouth opening

The assessment of voluntary mouth opening showed no significant differences between individuals during Week 0 (pretreatment; $p>0.05$). During the post-treatment evaluation in the same week, the L group (−5.594, $p<0.0001$) and OSL group (−3.303, $p=0.0068$) achieved greater gains in mouth opening, with no significant differences between the groups ($p>0.05$).

In Week 2, the L and OSL groups exhibited greater mouth opening than the OS group during the pretreatment period ($p<0.05$). The intergroup evaluation confirmed this trend, with higher post-treatment values ($p<0.05$) than in the OS group. The intragroup evaluation showed that the L group (−1.688, $p=0.0116$) and OSL group (−1.438, $p=0.0395$) achieved greater gains in mouth opening between pretreatment and post-treatment of Week 2 ($p<0.05$).

During Week 4, no group showed a statistically significant difference in either the pretreatment or post-treatment

A	Group (Mean ± SD)		
	OS	L	OSL
Week 0	**(n=34)**	**(n=32)**	**(n=33)**
Baseline	3.824 ± 2.455[a]	3.844 ± 2.384[a]	3.333 ± 2.102[a]
Post-treatment	3.265 ± 2.550[a]	2.063 ± 2.213[ab]	1.848 ± 1.889[b]
Mean difference	0.5588	1.781	1.485
Value of p	0.3039	<0.0001*	0.0002*
Week 2	(n=34)	(n=32)	(n=32)
Baseline	2.559 ± 2.489[a]	3.188 ± 2.693[a]	2.219 ± 2.393[a]
Post-treatment	2.706 ± 2.553[a]	1.594 ± 1.998[ab]	1.156 ± 1.588[b]
Mean difference	-0.1471	1.594	1.063
Value of p	0.9351	<0.0001*	0.0011*
Week 4	(n=33)	(n=32)	(n=33)
Baseline	1.061 ± 1.273[a]	1.813 ± 2.221[a]	1.758 ± 2.222[a]
Post-treatment	1.303 ± 1.571[a]	0.875 ± 1.621[a]	0.6667 ± 1.109[a]
Mean difference	-0.2424	0.9375	1.091
Value of p	0.6084	0.0002*	<0.0001*
Week 12	(n=33)	(n=32)	(n=33)
Re-evaluation	0.727 ± 1.48[c]	2.50 ± 2.54[d]	1.64 ± 1.83[cd]

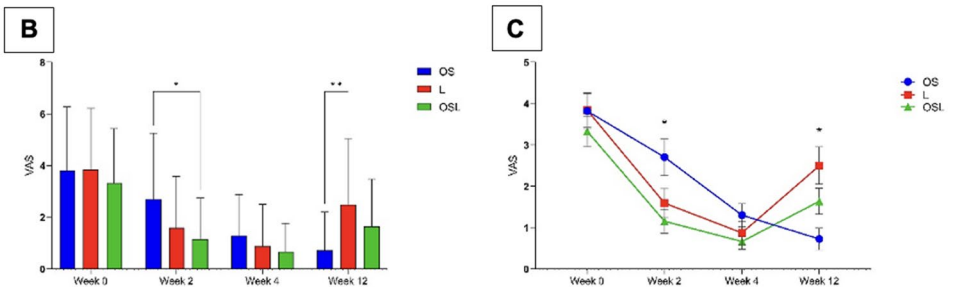

Fig. 3 Self-reported pain assessment (VAS). **A**: Self-reported pain assessment (VAS). **B**: Intergroup assessment of self-reported pain– two-way ANOVA complemented by Tukey's test (mean ± SD). **C**: Longitudinal monitoring of self-reported pain assessment (mean ± SEM). VAS: visual analogue scale, OS: occlusal splint, L: laser, OSL: occlusal splint + laser, SD: standard deviation. *Significant intragroup differences between baseline and post-treatment ($p<0.05$)– two-way ANOVA complemented by Šídák's test. Different letters indicate significant differences between groups ($p<0.05$)– two-way ANOVA complemented by Tukey's test. [cd]Different letters indicate significant differences between groups ($p<0.05$)– one-way ANOVA complemented by Tukey's test

	Group (Mean ± SD		
	OS	L	OSL
Week 0	3.824 ± 2.455[a]	3.844 ± 2.384[a]	3.333 ± 2.102[a]
Week 4	1.303 ± 1.571[a]	0.875 ± 1.621[a]	0.6667 ± 1.109[a]
Mean difference	2.530	2.969	2.667
Value of p	<0.0001*	<0.0001*	<0.0001*
Week 0	3.824 ± 2.455[a]	3.844 ± 2.384[a]	3.333 ± 2.102[a]
Week 12	0.727 ± 1.48[a]	2.50 ± 2.54[b]	1.64 ± 1.83[ab]
Mean difference	3.105	1.344	1.697
Value of p	<0.0001*	0.0074*	0.0004*

Fig. 4 Assessment of self-reported pain (VAS) between Week 0 pre-treatment and Weeks 4 and 12 post-treatment. VAS: visual analogue scale, OS: occlusal splint, L: laser, OSL: occlusal splint + laser, SD: standard deviation. *Significan intragroup differences between post-treatment sessions ($p < 0.05$)– two-way ANOVA complemented by Šídák's test. Different letters indicate significant differences between groups ($p < 0.05$)– two-way ANOVA complemented by Tukey's test

intergroup assessment ($p > 0.05$). However, the L group (−2.094, $p = 0.006$) demonstrated greater gains in mouth opening between pretreatment and post-treatment during this period.

After 12 weeks, during the participants' reassessment, all groups showed similar values for voluntary mouth opening ($p > 0.05$) (Fig. 5).

It is noteworthy that all three treatment modalities promoted gains in voluntary mouth opening between the pre-treatment session at Week 0 and the post-treatment sessions at Weeks 4 and 12 ($p < 0.05$), with no statistically significant differences observed between the groups after 4 or 12 weeks ($p > 0.05$).

Oral health impact profile (OHIP-14)

Throughout the sessions, all groups showed a statistically significant reduction in OHIP-14 scores from the beginning of treatment (Week 0) to the last session (Week 4), and again during the reassessment at Week 12 ($p < 0.0001$). Statistically significant differences were also observed between the groups throughout the treatment ($p < 0.05$). In Week 0, participants in the L group had higher OHIP-14 scores (24.63 ± 9.09) than those in the OSL group (20.48 ± 6.37, $p < 0.05$). At Week 4, no statistically significant differences were noted between the groups ($p > 0.05$). However, during the Week 12 reassessment, participants in the L group reported higher scores (12.73 ± 5.31) than both the OS group (8.63 ± 5.06) and the OSL group (8.15 ± 4.50). Finally, there was no significant change in OHIP-14 scores between Week 4 and Week 12 ($p > 0.05$) (Fig. 6).

Discussion

This clinical trial evaluated the effects of conservative therapies—OS and PBMT—both individually and in combination for the treatment of TMD. The results demonstrated that all three approaches were effective in reducing TMD parameters, validating the PBMT protocol used (including its dosimetric and localized irradiation parameters) and confirming its efficacy [5, 8, 29, 30].

The demographic analysis revealed an average age of 31 years, with a larger proportion of female participants. This aligns with findings from other studies that report a higher prevalence of TMD in adults during their 20s and 30s, with women being particularly affected [1, 3, 13, 21, 22, 29, 31–35]. Such differences may be associated with endocrine, hormonal, and behavioral factors [13, 31, 34].

Among conservative therapies, the OS is the most well-documented and widely used modality [36, 37]. The fabrication method using the mixed technique in this study yielded satisfactory results, such as reducing laboratory steps, enabling quick fabrication and installation, and ensuring cost-effectiveness [17, 37]. Its potential for broader social application should be noted despite the fact that it is not extensively discussed in the current literature.

However, despite being recommended as a first-line treatment, OS does not demonstrate efficacy in all cases, and its success is largely dependent on patient compliance [8, 15]. In this context, our findings regarding PBMT align with the literature, which supports its use for its analgesic, anti-inflammatory, and reparative properties, showing significant clinical improvement in patients [1, 19]. The PBMT is considered a clinically safe, non-invasive therapeutic option that is practically free of side effects [10, 12, 14].

Regarding dosimetry, systematic reviews indicate that while there is insufficient evidence to determine an ideal dosage, parameters such as the use of infrared light with

A	Group (Mean ± SD)		
	OS	L	OSL
Week 0	(n=34)	(n=32)	(n=33)
Baseline	41.76 ± 8.435[a]	38.72 ± 9.643[a]	41.79 ± 7.574[a]
Post-treatment	43.32 ± 7.850[a]	44.31 ± 7.271[a]	45.09 ± 7.099[a]
Mean difference	-1.559	-5.594	-3.303
Value of p	0.3563	<0.0001*	0.0068*
Week 2	(n=34)	(n=32)	(n=32)
Baseline	43.85 ± 7.978[a]	48.19 ± 6.949[b]	49.16 ± 7.283[b]
Post-treatment	44.68 ± 8.587[a]	49.88 ± 6.554[b]	50.59 ± 6.603[b]
Mean difference	-0.8235	-1.688	-1.438
Value of p	0.3633	0.0116*	0.0395*
Week 4	(n=33)	(n=32)	(n=33)
Baseline	45.00 ± 8.682[a]	44.31 ± 7.798[a]	45.09 ± 8.379[a]
Post-treatment	45.94 ± 8.703[a]	46.41 ± 8.312[a]	46.58 ± 8.419[a]
Mean difference	-0.9394	-2.094	-1.485
Value of p	0.3883	0.006*	0.0714
Week 12	(n=33)	(n=32)	(n=33)
Re-evaluation	47.00 ± 8.235[c]	45.44 ± 7.388[c]	46.85 ± 7.698[c]

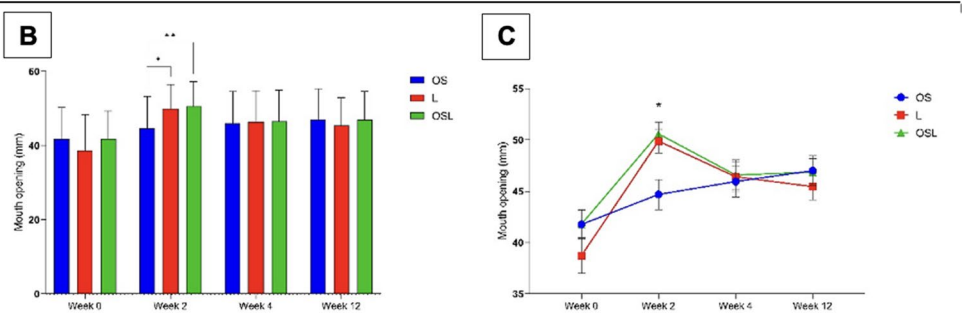

Fig. 5 Assessment of voluntary mouth opening (mm). **A**: Assessment of voluntary mouth opening (mm). **B**: Intergroup assessment of spontaneous mouth opening– two-way ANOVA complemented by Tukey's test (mean ± SD). **C**: Longitudinal monitoring of the assessment of spontaneous mouth opening (mean ± SEM). OS: occlusal splint, L: laser, OSL: occlusal splint + laser, SD: standard deviation. *Significant intragroup differences between baseline and post-treatment ($p < 0.05$)– two-way ANOVA complemented by Šídák's test. Different letters indicate significant differences between groups ($p < 0.05$)– two-way ANOVA complemented by Tukey's test. [c]One-way ANOVA complemented by Tukey's test

a wavelength of 780–980 nm are consistent with those applied in the present study [2, 10, 11]. These findings are also supported by clinical studies, which validate the use of these parameters for effective treatment [8, 9, 19, 20, 30, 32]. Additionally, it is crucial to emphasize that the application should be performed symmetrically; improper application on one side can lead to an overload on the opposite side, potentially causing delayed pain and adversely affecting clinical outcomes [1, 25].

Given the complexity of TMD and the variability in patient responses to treatment, the literature highlights the heterogeneity of laser protocols used in different studies, including variations in the number of sessions, frequency, and wavelength [9, 21, 38]. By building upon an established protocol, this study provides new insights and validates existing practices with concrete, safe, and applicable data [25].

The study demonstrated an immediate reduction in self-reported pain levels in the groups receiving PBMT treatment when compared to those treated with OS alone. This can be attributed to the short-term effects of laser therapy. However, all therapies were effective in controlling pain throughout the treatment, consistent with existing literature [37]. In the 12-week reevaluation, the OS group showed greater effectiveness in pain control compared with PBMT alone. This may be due to the continuous use of the device leading up to the reevaluation, indicating that consistent use helps maintain stability in the evaluated parameters.

Mandibular mobility, another parameter evaluated, was also superior in the groups treated with PBMT compared with the isolated use of OS early in the treatment. However, during the reevaluation, all modalities resulted in significant gains in mouth opening across groups, consistent with the literature. This demonstrates that when mandibular mobility is limited, the use of PBMT is effective in quickly restoring the normal opening pattern [1, 9, 26].

Symptoms of TMD can negatively impact an individual's perception of their physical, mental, and social well-being [39]. The application of the OHIP-14 questionnaire, as demonstrated in Ekici's work, shows that levels of stress,

A	Group (Mean ± SD)		
	OS	L	OSL
T0	23.55 ± 8.779[ab]	24.63 ± 9.091[a]	20.48 ± 6.374[b]
T4	9.485 ± 5.403[a]	11.33 ± 6.048[a]	8.727 ± 5.014[a]
Mean difference	14.06	13.30	11.76
p-value	<0.0001*	<0.0001*	<0.0001*
T0	23.55 ± 8.779[ab]	24.63 ± 9.091[a]	20.48 ± 6.374[b]
T12	8.636 ± 5.067[a]	12.73 ± 5.317[b]	8.152 ± 4.501[a]
Mean difference	14.91	11.90	12.33
p-value	<0.0001*	<0.0001*	<0.0001*
T12	8.636 ± 5.067[a]	12.73 ± 5.317[b]	8.152 ± 4.501[a]
Mean difference	0.8485	-1.40	0.5758
p-value	0.7618	0.5112	0.8821

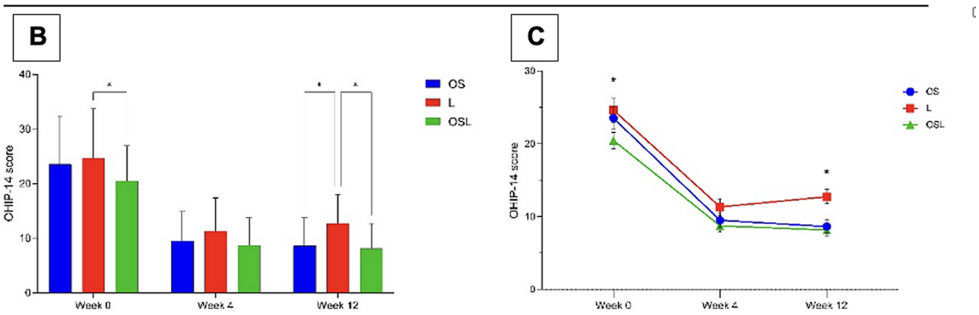

Fig. 6 Oral Health Impact Profile (OHIP-14) assessment between Week 0 pretreatment and Weeks 4 and 12 post-treatment. **A**: Oral Health Impact Profile (OHIP-14) assessment between Week 0 pretreatment and Weeks 4 and 12 post-treatment. **B**: Intergroup assessment of OHIP-14 scores– two-way ANOVA complemented by Tukey's test (mean ± SD). **C**: Longitudinal monitoring of OHIP-14 scores (mean ± SEM). OS: occlusal splint, L: laser, OSL: occlusal splint + laser, SEM: standard error of the mean, SD: standard deviation. *Statistically significant difference ($p < 0.05$). *Significant intragroup differences between baseline and post-treatment ($p < 0.05$)– two-way ANOVA complemented by Šídák's test. [ab]Different letters indicate significant intergroup differences ($p < 0.05$)– two-way ANOVA complemented by Tukey's test

anxiety, and depression are strongly associated with quality of life in patients with TMD, highlighting the importance of assessing psychosocial factors in the treatment of this disease to improve overall quality of life [28]. The outcomes of this study indicate that although the L group had higher scores during reassessment, all groups experienced significant improvements in quality of life, aligning with findings from other clinical studies [26, 30, 34].

One limitation of this study was the inability to implement blinding for the researchers administering the therapies and the participants, due to the inherent nature of the interventions. Additionally, while this study focused on comparing treatment groups, the inclusion of a control group consisting of healthy individuals without TMD could have provided a more robust baseline for comparison, allowing for a clearer differentiation between treatment effects and normal physiological variations. However, the sample size employed in this study strengthens the robustness and reliability of its findings. Future research should focus on evaluating the efficacy of conservative therapies, both individually and in combination, for the management of TMD.

These therapeutic modalities, being both low-cost and low-complexity, hold significant social value, making treatment accessible to more people. This is particularly important in areas with limited dental services because they provide an effective and affordable option for alleviating TMD symptoms and improving quality of life.

Conclusion

The conservative treatments assessed in this study proved effective in enhancing pain management, mandibular mobility, and the quality of life related to oral health in individuals diagnosed with muscular TMD. The combination of PBMT and OS yielded superior outcomes compared to the isolated application of each therapy. The PBMT provided immediate pain relief, while the continuous use of OS contributed to the long-term stabilization of symptoms.

This study is significant because it addresses the need for robust evidence on the combined use of these conservative therapies, particularly in an area where treatment protocols lack standardization. By providing a validated and applicable protocol, this research offers critical insights into effective and accessible treatments for TMD, emphasizing the potential social value of low-cost, non-invasive options. This is particularly important for underserved populations with limited access to specialized dental care, underscoring the study's importance in improving the quality of life for a broader group of patients.

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Declarations

Ethical approval The protocol was approved by the study institution's Human Subjects Research Ethics Committee (opinion no. 66265922.7.0000.5142) and registered on Plataforma Brasil (CAAE: 66265922.7.0000.5142). The present study was described following the CONSORT guidelines for randomized trials (NCT05989217 Clinical Trials Protocol registration).

Consent to participate After being informed about all the research details, all participants signed the Free and Informed Consent Form, as required by the Brazilian National Board of Health. In this manuscript, no individual data or information that could identify any of the participants were reported.

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

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