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Therapeutic Effects of Low-Level Laser Therapy (635 nm), Ultrasound, and Combination Therapy on Pain and Function in Patients with Temporomandibular Joint Disorders

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ABSTRACT

Objective : This study aimed to investigate and compare the therapeutic efficacy of low-level laser therapy (LLLT) (635 nm), ultrasound (US), and combination therapy in alleviating pain and improving functional outcomes in patients with temporomandibular joint disorders (TMDs), identifying the most effective modality for managing temporomandibular joint disorder (TMD)-related pain and dysfunction.

Methods: A total of 75 Patients diagnosed with TMD were randomly assigned to three treatment groups. Group 1 received laser therapy (635 nm) at 0.3 Watts (W) for 30 seconds per tender point. Group 2 received ultrasound therapy at 0.2 Watts (W) for 30 minutes per application. Group 3 underwent combination therapy (laser 635 nm and ultrasound). Each participant received four treatment sessions (two per week) and was followed up after one month. Clinical assessments included the number of tender sites, mouth opening measured with an electronic digital calliper, and pain intensity recorded using a visual analogue scale. Data was analysed using appropriate statistical methods

Results: Patients in the laser therapy group (635 nm) exhibited a statistically significant reduction in pain intensity (P=0.000) at all assessment points, including post-treatment and one-month follow-up. This group demonstrated the most pronounced pain reduction, outperforming the combination and ultrasound groups. Similarly, mouth opening significantly improved in the laser therapy group (P=0.010, P=0.000) at pre-third session, pre-fourth session, and one-month post-treatment, followed by the combination therapy and ultrasound groups.

Conclusion :Low-level laser therapy (635 nm) effectively reduces pain and enhances mouth opening in patients with TMD. The findings suggest that LLLT is a promising non-invasive treatment for temporomandibular joint disorder (TMD)-related pain and dysfunction, with combination therapy providing additional benefits. Further research is needed to optimize LLLT protocols and explore long-term outcomes.

Keywords: *Temporomandibular joint disorders (TMDs), Low-level laser therapy (635 nm), Ultrasound, Combination therapy, Pain intensity.*

1. INTRODUCTION

Temporomandibular disorders (TMDs) encompass a spectrum of conditions affecting the temporomandibular joint (TMJ) and associated musculature, often resulting in pain, restricted jaw movement, and functional impairment [1,2,3]. Additionally, people with TMD may hear a clicking or popping sound when opening or closing their mouths [4,5]. The etiology of TMDs is multifactorial, involving parafunctional habits, psychological stress, trauma, and occlusal abnormalities [6]. (TMDs) are more common in women, particularly those aged 20 to 40, with a female-to-male prevalence ratio of approximately 2:1[7]. Diagnosis relies on clinical assessment, patient history, and imaging techniques [8]. The primary objectives of treating individuals with temporomandibular disorders (TMD) are to relieve pain, restore normal chewing function, enhance jaw mobility, and improve the patient's overall quality of life [9]. Despite the availability of various treatment modalities, an optimal therapeutic approach remains elusive. Non-invasive treatments such as transcutaneous electrical nerve stimulation (TENS), ultrasound, and low-level laser therapy (LLLT) have demonstrated potential efficacy [10,11]. Low-level laser therapy (LLLT), a form of phototherapy that promotes biological processes and alleviates pain without causing significant temperature changes [12,13], has gained attention for its ability to modulate cellular responses,

reduce inflammation, and promote tissue regeneration, making it a promising modality for TMD management [14,15,16]. Ultrasound therapy has also been utilized in TMD treatment due to its mechanical and thermal effects, which enhance blood flow and reduce muscular tension [17]. However, the comparative effectiveness of these modalities remains unclear. This study aims to assess and compare the efficacy of LLLT (635 nm), ultrasound, and their combination in managing TMD-related pain and functional impairment.

2. MATERIALS AND METHODS

Study Design and Setting :This randomized clinical trial was conducted at the Department of Oral and Maxillofacial Surgery, Al Imam Ali Hospital, and a specialized oral medicine clinic in Baghdad from January to August 2024. Ethical approval was obtained from the Laser Institute's Research Scientific Committee (Ref. No. 1329, 23/09/2024), and all participants provided informed consent

Participants :Seventy-five patients (64 females, 11 males) aged 20–29 years with a confirmed diagnosis of muscular TMD were enrolled. Inclusion criteria included the presence of pain, limited mouth opening, and tenderness in the masseter and temporalis muscles. Patients with congenital TMJ abnormalities, recent trauma, occlusal issues, neoplastic conditions, or prior treatment within the last month were excluded.

Ultrasound and laser components

Figures (1a) and (1b) illustrate the following accessories for laser and ultrasonic devices:

1. Wireless footswitch
2. Front view of the base unit
3. Laser-protective eyewear
4. Therapy handpiece
5. Patient’s goggle

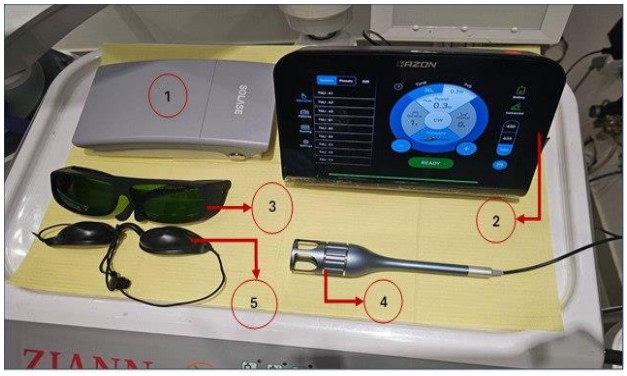

Figure (1a): Solase Pro dental laser

Figure (1b): ultrasound device 1. Ultrasound applicator 2. Electrotherapy cart

Ultrasound and laser system

The laser system used was a Solase dental diode laser with 635 nm wavelengths, production date 24.07.2023, while the ultrasound was a Chattanooga brand, year of establishment: 2021.

Treatment Protocols

LLLT Group (Laser 635 nm): Applied at 0.3 W, with a light spot diameter of 2 cm, the power density per point was 0.0955 W/cm², and an irradiation time of 30 seconds per tender point in continuous mode. As shown in figure (2a).

Ultrasound Therapy Group: Applied at 0.2 W, with an applicator size of 2 cm², a power density of 0.1 W/cm², a frequency of 1 MHz, and 3 minutes per masseter tender point in continuous mode. As shown in figure (2b).

Combination Therapy Group: LLLT was administered first, followed immediately by ultrasound therapy.

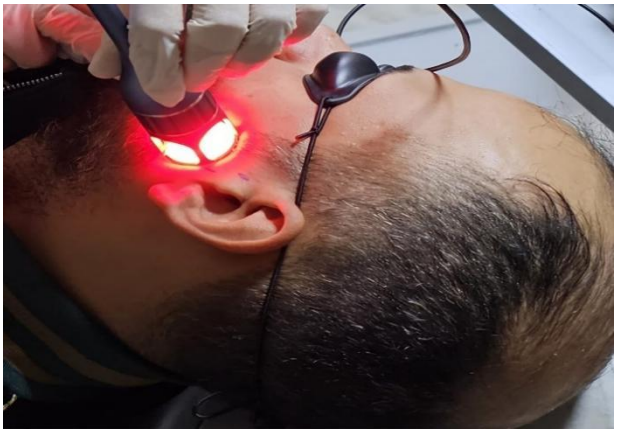

Figure (2a): Application of red laser 635 nm on joint area and masseter tender points

Figure (2b): Application of ultrasound therapy (circular motion) on all masseter tender points

Clinical Assessment

Utilized the Research Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for treatment evaluation.

Pain intensity: Measured using the Visual Analog Scale (VAS; 1–10 scale.

Mouth opening: Assessed with an electronic digital caliper.

Tender sites: Identified via palpation.

3. STATISTICAL ANALYSIS

Data were analyzed using the Statistical Package for Social Sciences(SPSS) version 26. The Kruskal-Wallis test was used for non-normally distributed data. A P-value of ≤0.05 was considered statistically significant.

4. RESULTS

Demographics Participants had a mean age of 28.7 ± 8.4 years, with a predominance of females (85.3%) (64). As shown in Figures (3), and (4).

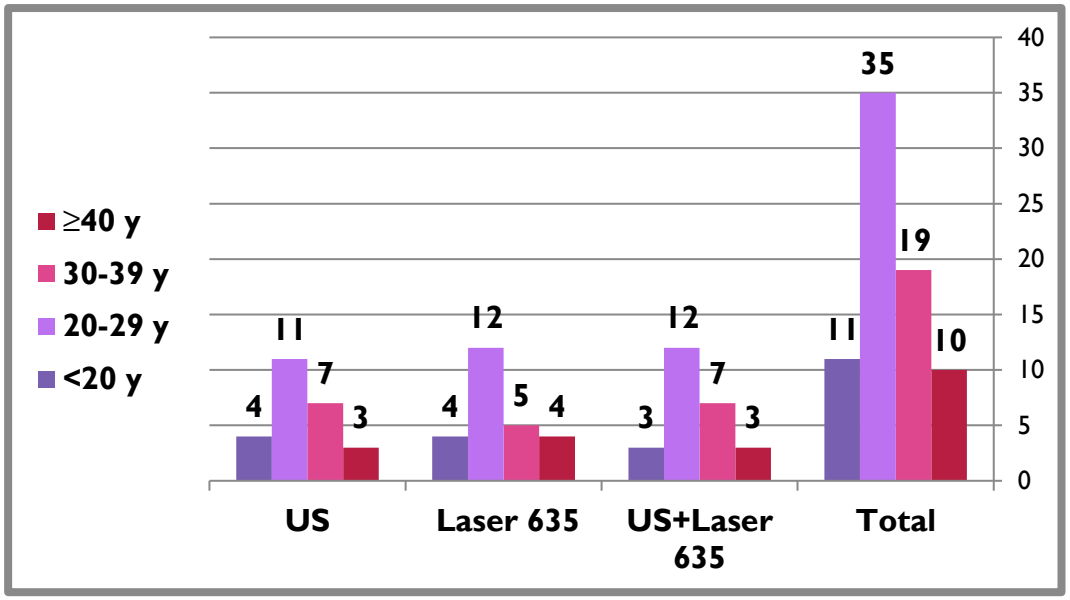

Figure 3: Distribution of participants according to age group, Baghdad, 2024.

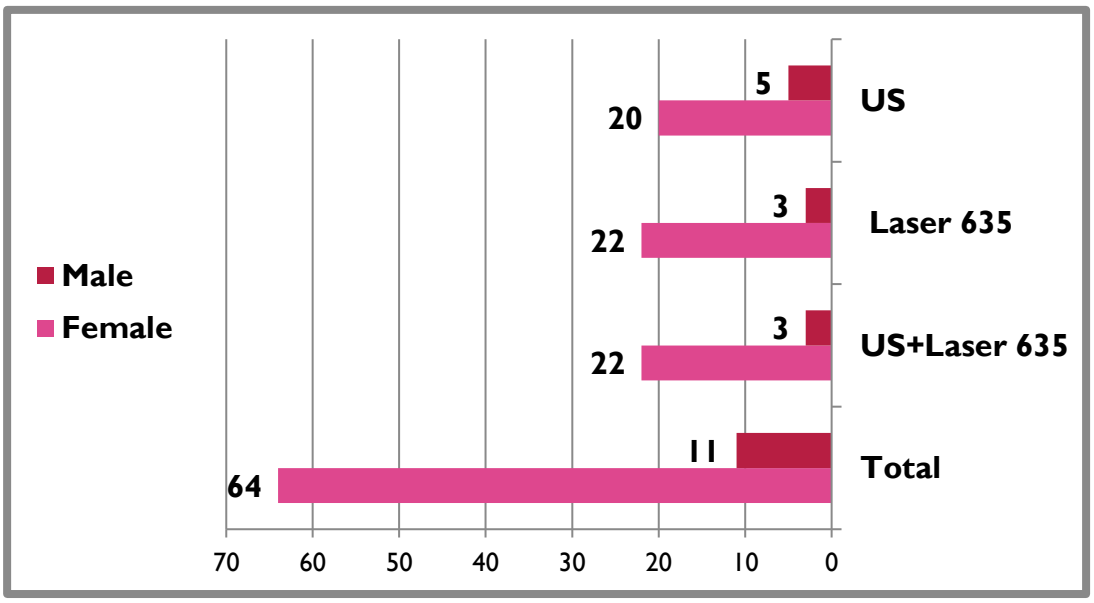

Figure 4: Distribution of participants according to gender, Baghdad, 2024.

Table 1: Comparison of Therapeutic Effects on Pain and Function Among Treatment Groups at Different Periods, Baghdad, 2024.

Variable	Ultrasound	Laser 635±10	Ultrasound/Laser 635±10	P value
	Mean±SD	Mean±SD	Mean±SD	
Before first session				
Pain intensity	6.0±1.1	5.4±1.2	6.4±0.9	0.006*
Mouth opening	37.4±3.9	39.1±7.4	37.6±4.9	0.364
Before second session				
Pain intensity	5.2±1.3	3.9±1.2	5.2±1.0	0.000*

Mouth opening	37.4±3.9	40.4±6.8	38.7±3.0	0.084
Before third session				
Pain intensity	5.0±1.5	3.0±1.1	4.1±1.1	0.000*
Mouth opening	38.0±4.0	42.0±6.1	39.3±3	0.010*
Before fourth session				
Pain intensity	4.5±1.7	2.2±1.1	3.2±1.3	0.000*
Mouth opening	38.5±3	43.4±4.6	39.8±2.7	0.000*
One month follow-up				
Pain intensity	4.2±2.0	1.3±1.3	1.6±1.4	0.000*
Mouth opening	38.5±3.0	43.6±4.8	39.9±3.0	0.000*

*Significant result Kruskal-Wallis test used

Comparative Analysis of Therapeutic Effects

Pain Intensity: The LLLT group exhibited the most significant pain reduction across all sessions (P=0.000). The combination therapy group showed moderate improvement, while the ultrasound group had the least reduction.

Mouth Opening: Mouth opening significantly improved in the LLLT group (P=0.010, P=0.000), followed by the combination therapy and ultrasound group.

5. DISCUSSION

This study investigated and compared the therapeutic effects of low-level laser therapy (635 nm), ultrasound therapy, and combination therapy on pain intensity and mouth opening in patients with temporomandibular joint disorders (TMDs). The findings revealed significant differences in both pain reduction and functional improvement across all treatment modalities, with low-level laser therapy (635 nm) demonstrating the most substantial therapeutic effects.

The findings of our study indicate that the highest incidence of temporomandibular joint disorders (TMD) was observed in the 20–29-year age group, with a rate of 35(46.7%). This result aligns closely with the findings of Valesan et al. (2021) who reported that 41% of TMD patients were within the age group over 18 years [18]. Similarly, Al-Jewair et al. (2021) noted that TMD prevalence peaks between the ages of 20 and 40, affecting approximately 20–60% of children and adolescents [19]. Our study found that females had a significantly higher incidence of temporomandibular joint disorders (TMDs), comprising 64 of the cases, while males accounted for 11. This finding aligns with other studies, which also report a higher prevalence of TMD in females. Hormonal factors, particularly estrogen, have been suggested to influence condylar morphology and joint health, as highlighted by Stinson et al. (2021) [20,21]. Moreover, Hauru et al. (2022) showed that low estradiol levels affect proteoglycan levels in mandibular condyle cartilage, providing a potential biological explanation for the gender disparity in TMD prevalence [22]. The primary signs and symptoms of temporomandibular disorders (TMD) include pain in the temporomandibular joint, the muscles involved in chewing, and restricted mouth movement. A restricted mouth opening is defined as any distance below 40 mm [23,24]. TMD pain is affected by neurological issues like irregular pain processing and heightened sensitivity, inflammatory mediators such as prostaglandins and cytokines, and psychological factors like stress and anxiety [25,26]. This study corroborates previous findings that LLLT (635 nm) effectively reduces pain and improves function in TMD patients. The results align with prior studies indicating the efficacy of LLLT in TMD management [27,28,29,30]. The selection of the 635 nm wavelength in this study was deliberate, based on its established biophysical properties and reported efficacy in treating musculoskeletal pain, particularly TMDs [31, 32]. Low-level laser therapy (LLLT) at 635 nm is a non-thermal treatment proven effective in reducing pain and promoting tissue repair in temporomandibular disorders (TMDs) [29,33]. The 635 nm wavelength falls within the "red light" portion of the electromagnetic spectrum, a range known for its optimal absorption characteristics in biological tissues [31, 32]. This wavelength is readily absorbed by hemoglobin and melanin, chromophores in skin and muscle tissue, leading to localized energy transfer and subsequent photobiomodulation [31,32,34,35]. It interacts directly with cytochrome c oxidase (CcO) in mitochondria, which enhances ATP production [28, 35], increasing tissue oxygenation, and improving cellular energy levels. The effects include stimulated cell proliferation, growth factor release [34,35], reduced oxidative stress, and modulation of inflammatory responses by lowering prostaglandin levels [28,29]. These mechanisms promote tissue repair and accelerate recovery in musculoskeletal conditions like TMDs [27, 31, 32,33,34]. The observed benefits of combination therapy suggest a synergistic effect between LLLT and ultrasound, LLLT targets cellular pain, while ultrasound enhances tissue heating and

blood flow for improved recovery [36,37,38]., though LLLT alone remains superior [39,40]. The findings also reinforce that ultrasound therapy, while beneficial [41,42], is less effective than LLLT in managing TMD symptoms. The outcomes support the hypothesis that photobiomodulation enhances mitochondrial function and cellular repair, leading to improved pain relief and tissue healing [39,40].

Conclusions and Clinical Implications: This study confirms the efficacy of LLLT (635 nm) in reducing pain and improving mouth opening in TMD patients. While combination therapy provides additional benefits, LLLT alone remains the most effective modality. Clinicians should consider LLLT as a primary treatment for TMD, with combination therapy as an adjunct for patients requiring enhanced functional recovery. Future studies should explore long-term effects and optimize treatment protocols.

Ethical Considerations Ethics Approval: Approved by the Institute of Laser for Postgraduate Studies (Ref. No. 1329, 23/09/2024). Funding: No external funding was received. Consent for Publication: Not applicable

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